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Preliminary Data Summary for the Hazardous Waste Treatment Industry

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This document is one of a series of Preliminary Data Summaries prepared by the Office of Water Regulations and Standards of the U. S. Environmental Protection Agency. The Summaries contain engineering, economic and environmental data that pertain to whether industrial facilities in various industries discharge pollutants in their wastewaters and whether the EPA should pursue regulations to control such discharges. The summaries were prepared in order to allow EPA to respond to the mandate of Section 304(m) of the Clean Water Act, which requires the Agency to develop plans to regulate industrial categories that contribute to pollution of the Nation's surface waters. Summaries for categories already subject to rulemaking were developed for comparison purposes, and contain only the minimum amount of data needed to provide some perspective on the relative magnitude of the pollution problems created across the categories.

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PRELIMINARY DATA SUMMARY
FOR THE
HAZARDOUS WASTE TREATMENT INDUSTRY

Office of Water Regulations and Standards
Office of Water
United States Environmental Protection Agency
Washington, D.C.

September 1989

PREFACE

This is one of a series of Preliminary Data Summaries prepared by the Office of Water Regulations and Standards of the U.S. Environmental Protection Agency. The Summaries contain engineering, economic and environmental data that pertain to question as to whether the industrial facilities in various industries discharge pollutants in their wastewaters and whether the EPA should pursue regulations to control such discharges. The summaries were prepared in order to allow EPA to respond to the mandate of section 304(m) of the Clean Water Act, which requires the Agency to develop plans to regulate industrial categories that contribute to pollution of the Nation's surface waters.

The Summaries vary in terms of the amount and nature of the data presented. This variation reflects several factors, including the overall size of the category (number of dischargers), the amount of sampling and analytical work performed by EPA in developing the Summary, the amount of relevant secondary data that exists for the various categories, whether the industry had been the subject of previous studies (by EPA or other parties), and whether or not the Agency was already committed to a regulation for the industry. With respect to the last factor, the pattern is for categories that are already the subject of regulatory activity (e.g., Pesticides, Pulp and Paper) to have relatively short Summaries. This is because the Summaries are intended primarily to assist EPA management in designating industry categories for rulemaking. Summaries for categories already subject to rulemaking were developed for comparison purposes, and contain only the minimal amount of data needed to provide some perspective on the relative magnitude of the pollution problems created across the categories.

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1. FOREWORD

The Industrial Technology Division (ITD) of the U.S. Environmental Protection Agency (EPA) has conducted a study of the hazardous waste treatment industry as a result of findings from the Domestic Sewage Study. The purpose of this study is to develop information to characterize the hazardous waste treatment industry as to the scope of the industry, its operations, its dischargers to the Nation's waters, and identification and quantification of the pollutants discharged to the Nation's waters.

The Agency collected data and information from a variety of sources from which conclusions were drawn. The information gathering efforts of the Agency were supplemented by efforts of the Office of Research and Development (ORD), the Office of Solid Waste (OSW), local governments, and the states. Wastewater sampling was conducted at twelve sites and the data collected represent the best available for characterizing the industry. Analyses were conducted for over 400 conventional, nonconventional, priority, and Resource Conservation and Recovery Act (RCRA) pollutants.

Since this report was initially prepared, the Office of Water Regulations and Standards has continued to obtain information about the industry, particularly through analysis of responses to the National Survey of Hazardous Waste Treatment, Storage, Disposal, and Recycling (TSDR) Facilities conducted by the U.S. EPA Office of Solid Waste. The TSDR Survey data provides a good deal of new information on wastewater treatment and the other processes used to manage hazardous waste, including counts of facilities carrying out the various hazardous waste management processes and data for the volume of liquid residuals. As this new material is considered, the scope of the Agency's rulemaking efforts for hazardous waste treatment facilities will be determined.

2. SUMMARY

- The hazardous waste treatment (HWT) industry was divided into three subcategories:
    - Landfills with leachate collection and treatment facilities
    - Incinerators with wet scrubbers
    - Aqueous hazardous waste treaters

- The number of facilities in each subcategory was estimated as follows:

Subcategory	Number of Facilities
Landfills with leachate systems	911
Incinerators with wet scrubbers	273
Aqueous hazardous waste treaters	725

- The most common method of wastewater disposal for the landfill and aqueous hazardous waste treater subcategories was indirect discharge to Publicly-Owned Treatment Works (POTWs). Incinerators with scrubbers were more commonly direct dischargers. The breakdown of each subcategory by discharge method was estimated to be:

	Number of Facilities		
	Direct	Indirect	Other
Leachate	173	355	383
Wet Scrubbers	137	27	109
Aqueous Treaters	87	515	123

Other discharge included deep well injection, incineration, off-site disposal, land application, and solidification and reburial.

- EPA Regions V and VI had the largest number of hazardous waste landfills and incinerators. The largest number of aqueous waste treatment facilities were in EPA Region V.

- Observations made concerning raw landfill leachates include:
  - Some leachates contained very high concentrations (>100,000 μg/l) of toxic organic compounds.
  - The analytical methods used to identify and quantify organic pollutants in leachate may have a significant effect on which organics are identified and on the concentrations found.
  - Raw leachates were characterized by high concentrations of BOD5, COD, and TOC.
  - Volatile organics frequently were found in leachates, while non-volatile compounds may be present but were not readily detected.
  - Hazardous waste landfill leachates appeared to contain more toxic organic compounds than leachate from Subtitle D landfills, but this observation may be due to the list of analytes and/or analytical methodology problems. In terms of COD and TOC, however, there was no apparent difference between hazardous waste and Subtitle D landfills.
  - Leachate flow rates varied widely due in part to climatic and geological conditions, but were not related to the size of the landfill. Leachate flowrate was estimated to be 30,000 gpd for an "average" landfill and the reported range of flow was 0 to 94,000 gpd.
  - Leachates generally contained high concentrations of aluminum, iron, manganese, and boron, while the concentrations of toxic metals varied from below detection to over 100 mg/l.
  - Leachates from hazardous waste landfills appeared to contain higher concentrations of toxic metals than leachate from Subtitle D landfills.
- Raw wastewaters from the incinerator wet scrubber subcategory were characterized as follows:
  - Chemical characteristics of raw scrubber wastewaters were a function of the scrubber system operation. High ammonia concentrations were found in systems that use ammonia to neutralize acids. TSS concentrations were high in systems that did not use lime precipitation.
  - Raw scrubber wastewaters were characterized by low pH, high TDS, and high chlorides.

- Scrubber wastewaters contained high concentrations of metals. The metals detected at the highest concentrations include aluminum, iron, lead, zinc, mercury, and copper.

- Scrubber wastewaters contained very few organic pollutants.

- The average scrubber wastewater discharge was approximately 93,000 gpd, although flowrates could range as high as 350,000 gpd.

- Observations regarding the pollutants in raw aqueous hazardous wastes were as follows:

  - Aqueous hazardous wastes contained high concentrations of BOD_5, COD, and TOC.

  - Both metal and organic compounds were found in a wide range of concentrations and, in some cases, at very high concentrations.

  - The organics found most frequently and at the highest concentrations were industrial solvents (e.g., acetone, 2-butanone, methylene chloride, benzene, and toluene).

  - The metals found at the highest concentrations and most frequently were chromium, copper, nickel, zinc, iron, aluminum, boron, and manganese.

  - The wide range of concentrations of the toxic pollutants in the raw waste samples can be attributed to the high variability of wastes received and treated by these facilities.

  - Flowrates at facilities treating aqueous hazardous waste averaged 45,500 gpd and ranged from 13,600 to 117,000 gpd.

- A wide range of treatment technologies was employed for leachate treatment, including treatment and discharge, recirculation, solidification and reburial, deep well injection, and contract hauling.

- Advanced leachate treatment systems that involved biological treatment and physical/chemical effluent polishing processes were capable of achieving up to 90 percent removal of BOD_5, COD, TOC, ammonia, and TKN. These systems had achieved effluent BOD_5 concentrations of 10 mg/l or less. Even with advanced treatment systems, iron and boron effluent concentrations average over 1,000 µg/l. Treated leachate concentrations of other toxic metals were usually below 500 μg/l, frequently less than 100 μg/l. Significant metals removal occurred during the biological treatment process, as evidenced by the elevated concentrations of metals in the sludges. The metals with the highest concentrations in the sludges were those with high concentrations in the raw leachate (i.e., iron, manganese, aluminum). Boron, whose concentrations were frequently high in raw leachate, demonstrated relatively poor removal with high effluent concentrations and relatively low sludge concentrations.

- Scrubber wastewater treatment systems consisted of technologies designed for the removal of inorganic pollutants. Chemical precipitation/sedimentation provided metals removal, and filtration and carbon adsorption were used if necessary to polish portions of the effluents to meet permit limits. Consequently, no significant reduction in COD occurred, but effluent concentrations were relatively low. Even with advanced treatment, effluent concentrations of iron, manganese, boron, molybdenum, and zinc were above 1,000 μg/l. Effluent concentrations of the heavy metals were below 100 μg/l.

- In addition to treatment and disposal systems, other methods of scrubber wastewater disposal included landfill, evaporation, and contract hauling.

- Scrubber wastewater treatment system sludges were found to contain a large number of dioxin/furan isomers, some at extremely high concentrations. Dioxins/furans were relatively insoluble in water and tended to adsorb onto particulates. Although the treatment system effluents were not analyzed for dioxins/furans, these compounds may be discharged to POTWs or surface waters by way of the suspended solids in the treated effluents. Further analysis of treated effluents is needed to determine if the treatment technologies in-place were effectively removing dioxins/furans.

- Aqueous hazardous waste treatment systems ranged from precipitation/sedimentation units to advanced secondary and tertiary systems.

- Precipitation/sedimentation units at aqueous hazardous waste treaters achieve large reductions in heavy metals; however, toxic organics receive limited treatment and pass through the treatment system.

- Advanced treatment systems at aqueous hazardous waste treaters are more effective in removing organic compounds; however, high effluent concentrations of organic compounds are common even with advanced treatment. This conclusion is supported by high effluent concentrations of indicator pollutants such as BOD_5, TOC, and COD, which show relatively poor removals.

The relatively poor removal of TOC and BOD_5 by advanced treatment systems employing biological treatment and/or carbon adsorption indicates the potential for discharges of poorly treated hazardous wastes to POTWs or surface waters. Advanced treatment systems demonstrated metals removal efficiencies and effluent concentrations similar to those achieved by physical/chemical treatment systems.

- Many of the toxic organic pollutants accepted by aqueous hazardous waste treatment facilities are not effectively removed by physical/chemical or advanced treatment systems. Effluent concentrations of individual organic compounds can exceed 10,000 µg/l, even with advanced treatment technologies, such as carbon adsorption. Biological treatment is also relatively ineffective in the treatment of some organic compounds.

- High concentrations of a large number of isomers were found in the treatment sludges of aqueous waste treaters. However, the effluent samples were not tested for dioxins/furans. Dioxins/furans are relatively insoluble in water and tend to adsorb on particulates. High effluent TSS concentrations were found from both physical/chemical and advanced treatment systems, which indicates the potential for the discharge of these isomers. Sampling and testing of treatment system effluents for dioxins/furans is necessary to establish the concentrations of these compounds in treated effluent and the effectiveness of various treatment systems for their removal.

- Treatment costs were developed based on treatment technologies that correspond to common, typically sized, facilities operating in the HWT industry. Cost estimate developed for a typically sized facility in each subcategory are:

Subcategory	Investment, $	Operating Cost, $/yr	Annualized Cost, $/yr
Leachate Treatment	806,000	286,000	542,500
Scrubber Wastewater	1,501,000	381,000	854,300
Aqueous Treaters	767,000	325,000	569,600

- Leachate treatment could increase municipal landfill tipping fees.

- Implementation of the model wastewater treatment technologies would result in a net decrease in air emissions and increases in the amount of solid wastes generated and energy consumed. Air emissions potentially could be reduced by 39.6 million pounds of volatile pollutants per year. The amount of additional sludge generated could be as high as 380,000 metric tons per year. The amount of increased energy consumed as a result of possible regulations could total 91,000 barrels of No. 2 fuel per year. These conservative estimates assume that no treatment is currently in-place.

- The cost of implementing the model technologies was modest compared to average revenues for the HWT industry. The average incinerator would be required to increase revenues by 4.7 percent to cover control costs. A municipal landfill and hazardous waste landfill would increase tipping fees by 35.5 and 3.8 percent, respectively. An aqueous treater would be required to increase revenues by 3.0 percent to cover control costs.

- The toxic organic raw waste loads and metals raw waste loads for each subcategory, based on the total number of facilities in each subcategory, were estimated to be:

	Raw Waste Load, lb/year	
Subcategory	Total Toxic Organic	Total Metals
Leachate	50,090,000	35,500,000
Wet Scrubbers	353,000	26,940,000
Aqueous Treaters	23,680,000	406,150,000

- The raw waste loads for the regulated community (direct and indirect discharges only) were estimated to be:

	No. of Facilities		Raw Waste Load, lb/yr	
Subcategory	Direct	Indirect	Total Toxic Organics	Total Metals
Leachate	173	355	29,030,000	20,580,000
Wet Scrubbers	137	27	212,000	16,180,000
Aqueous Treaters	87	515	19,660,000	337,250,000

- Environmental impacts of the leachate subcategory, based on the combined data base from six independent studies, found of the total 215 pollutants detected, 111 were at levels that may be harmful to human health and/or aquatic life if discharged untreated directly into surface waters. Of the 111 pollutants (with exceedances), 70 would exceed human health criteria (41 for carcinogenicity protection, 29 for toxicity protection), 39 would exceed acute or short-term aquatic criteria/toxicity levels, and 87 would exceed chronic or long-term aquatic criteria/toxicity levels. In addition, 32 pollutants in untreated leachates would exceed existing/proposed EPA drinking water criteria. Most of these 111 pollutants have both human health and aquatic life impacts.

Indirect discharges of untreated leachates, based on projected discharge to a model 1 MGD POTW, may cause POTWs to exceed human health criteria for 24 pollutants (23 of these are carcinogens), drinking water criteria for 2 pollutants, and acute and chronic aquatic criteria/toxicity levels for 7 and 10 pollutants, respectively. In addition, 4 pollutants may have detrimental impacts on POTWs (4 causing POTW treatment inhibition, 1 causing sludge contamination problems). However, this analysis was based on limited POTW inhibition data and sludge criteria.

- Environmental impacts of the scrubber subcategory were evaluated using 1986-1987 EPA-ITD sampling data. This subcategory discharges 30 pollutants, of which 27 were detected at levels that would be harmful to human health and/or aquatic life if discharged untreated directly into surface waters. Of these 30 pollutants, 13 would exceed human health criteria (5 for carcinogenicity protection, 8 for human toxicity protection), 9 pollutants would exceed acute or short-term aquatic criteria/toxicity levels. In addition, 11 pollutants in untreated wastewaters are discharged at levels projected to exceed EPA existing/proposed drinking water criteria. Most of the 27 pollutants with exceedances are projected to impact both human health and aquatic life.

  Indirect discharges of untreated wastewater, based on projected discharge to a model 1 MGD POTW, may cause POTWs to exceed human health criteria for 3 pollutants and acute and chronic aquatic criteria toxicity levels for 6 and 7 pollutants, respectively. Six pollutants were projected to have detrimental impacts on POTWs (4 may cause inhibition, 6 may cause sludge contamination problems), based on limited inhibition data and sludge criteria.

- The environmental impacts of the aqueous subcategory, based on data from both the EPA-ITD and OSW studies, found the total number of pollutants with exceedances, as well as the number of human health, drinking water, and/or aquatic life exceedances for most of the pollutants, projected for direct discharges of untreated wastewater was 55. Of these 55 pollutants, 31 would exceed human health criteria (21 for carcinogenicity protection, 10 for toxicity protection), 22 would exceed existing/proposed EPA drinking water criteria, 17 would exceed acute or short-term aquatic life criteria/toxicity levels, and 36 would exceed chronic or long-term aquatic life criteria/toxicity levels.

  Indirect discharges of untreated wastewater, based upon projected discharge to a model 1 MGD POTW, may cause POTWs to exceed human health criteria for 12 pollutants (10 for carcinogenicity protection), acute aquatic life criteria/toxicity levels for 7 pollutants, chronic aquatic life criteria/ toxicity levels for 10 pollutants, and drinking water criteria for 4 pollutants in their receiving streams. In addition, six pollutants may have detrimental impacts on POTWs (6 causing POTW treatment inhibition, 6 causing sludge contamination problems).

3. INTRODUCTION

The study of hazardous waste treatment facilities is being conducted by the United States Environmental Protection Agency (USEPA) with assistance from Science Applications International Corporation (SAIC) under Contract No. 68-03-5309. The purpose of the study was to develop information to characterize the hazardous waste treatment (HWT) industry's scope, operations, and discharge to the Nation's waters, and to identify and quantify the pollutants in the discharge.

This study of the HWT industry was conducted under authority of Sections 301, 304, 306, 307, 308, and 501 of the Water Quality Act (WQA). In addition to regulations for designated industry categories, Section 307(a) of the WQA required promulgation of effluent standards applicable to all dischargers of toxic pollutants.

For the purposes of this study, the HWT industry has been defined as follows:

- Landfills with leachate collection and treatment facilities. In this study, the term leachate was used to describe all aqueous discharges from landfills. This discharge can include both leachates collected from the bottom of the landfill and any groundwater recovered at the site.
- Incinerators with wet scrubbers.
- Aqueous hazardous waste treaters.

3.1 SUMMARY OF HAZARDOUS WASTE REGULATIONS

Subtitle C of the Resource Conservation and Recovery Act (RCRA) of 1976 directed EPA to promulgate regulations to protect human health and the environment from the improper management of hazardous wastes. Based on this statutory mandate, the goal of the RCRA program is to provide comprehensive, "cradle-to-grave" management of hazardous waste. Key statutory provisions in RCRA Subtitle C include:

- Section 3001 - requiring the promulgation of regulations identifying the characteristics of hazardous waste and listing particular hazardous wastes

- Section 3002 - requiring the promulgation of standards (e.g., manifesting, recordkeeping, etc. applicable to generators of hazardous wastes
- Section 3003 - requiring the promulgation of standards (e.g., manifesting, recordkeeping, etc.) applicable to transporters of hazardous wastes
- Section 3004 - requiring the promulgation of performance standards applicable to the owners and operators of facilities for the treatment, storage, or disposal of hazardous wastes
- Section 3005 - requiring the promulgation of regulations requiring each person owning or operating a treatment, storage, or disposal facility (TSDF) to obtain a permit issued pursuant to Section 3005.

In 1980, EPA began promulgating regulations to implement these and other statutory directives contained in RCRA.

Under RCRA, waste management requirements are initially triggered by a determination that a waste is hazardous as defined in RCRA hazardous waste identification and listing regulations (40 CFR Part 261). Any party producing a hazardous waste is termed a generator under RCRA. A generator must provide notification to EPA and obtain an EPA identification number. Subsequent transportation, treatment, storage, or disposal of the wastes is subject to waste tracking requirements (i.e., manifesting requirements) and numerous other management requirements under RCRA. Any party, including the original generator, that treats, stores, or disposes of a hazardous waste also must provide notification to EPA and obtain an EPA identification number. These facilities, typically referred to as treatment, storage, and disposal facilities (TSDFs), are subject to extensive RCRA performance standards pertaining to the management of these wastes. Existing RCRA regulations contain performance standards for various types of treatment, storage, and disposal (TSD) units, including containers, tanks, surface impoundments, waste piles, land treatment units, landfills, and incinerators (40 CFR Parts 264 and 265). Moreover, TSDFs are required to obtain RCRA permits, known as Part B permits, to ensure their compliance with all applicable performance standards. Where a hazardous waste is transported off-site from a generator's premises, the transporter also is regulated by the hazardous waste management system and must comply with manifesting requirements to ensure delivery of the hazardous waste to an approved TSDF.

In interpreting relevant statutory provisions of RCRA, EPA has granted broad exemptions from RCRA requirements in areas relating to wastewater management. The three key wastewater exemptions include:

- Domestic sewage exclusion - excludes from regulation as either a solid or hazardous waste any mixture of domestic sewage and other wastes that passes through a sewer system to a POTW for treatment. Based on current Agency interpretation, the exemption begins when the waste first enters a sewer system that will mix it with sanitary wastes prior to POTW storage or treatment, but does not exclude industrial wastewaters while they are being collected, stored, or treated prior to discharge to a POTW.

- Direct discharge exclusion - excludes from regulation as either a solid or hazardous waste any industrial wastewater dischargers that are point source dischargers subject to regulation under WQA Section 402. This exemption begins when the wastewater is first discharged to surface waters, but does not exclude industrial wastewaters while they are being collected, stored, or treated prior to discharge to surface waters.

- Wastewater treatment exemption - exempts wastewater treatment units from TSDF performance standards and permitting requirements. A wastewater treatment unit is defined as a device that is part of a wastewater treatment facility subject to regulation under WQA Sections 402(a) or 307(b); treats or stores influent wastewaters or wastewater treatment sludges that are hazardous; and meets the definition of tank contained in 40 CFR Part 260. The term "tank" is defined as a stationary device constructed primarily of nonearthen materials (e.g., wood, concrete, steel, plastic) that provides structural support.

The basic rationale for these exemptions rests in the belief that most aspects of wastewater management systems can be adequately regulated under existing National Pollutant Discharge Elimination System (NPDES) and pretreatment provisions. Certain treatment units such as surface impoundments are nonetheless fully regulated under RCRA because of their potential effects on other environmental media, especially groundwater.

3.1.1 Regulation of Hazardous and Solid Waste Landfills

Landfill units currently are regulated under either Subtitle C or Subtitle D of RCRA, depending on the regulatory status of wastes managed at the landfill. RCRA Subtitle C hazardous waste regulations apply, with certain exceptions, to landfills that presently accept hazardous wastes or have accepted hazardous waste at any time after November 19, 1980. Technical standards for interim status hazardous waste landfills are contained in 40 CFR Part 265, Subpart N, while RCRA-permitted landfills are regulated under provisions contained in 40 CFR Part 264, Subpart N. These standards apply equally to on-site landfills maintained by hazardous waste generators, and off-site or commercial landfills that accept hazardous waste from generators on a commercial basis.

The 1984 Hazardous and Solid Waste Amendments (HSWA) to RCRA significantly strengthened controls on hazardous waste landfills by establishing minimum technology requirements. These provisions require the installation of double liner and leachate collection systems at new landfills, new landfills at existing facilities, replacements of existing units, and lateral expansion of existing units. While these provisions do not mandate costly retrofitting of existing portions of these landfills with liners and leachate collection systems, most hazardous waste landfills that retained interim status following the November 8, 1987, deadline for groundwater monitoring and financial responsibility certifications (i.e., the so-called loss of interim status certifications) already have installed leachate collection systems. Widespread installation of leachate collection systems at active hazardous waste landfills probably reflects a concern on the part of these facilities that any releases to groundwater from these units are likely to be detected by groundwater monitoring and may require expensive cleanup under RCRA corrective action provisions.

The extent of leachate collection by landfill units that lost interim status on November 8, 1986 is far less certain. While these landfills will be required to perform groundwater monitoring to comply with RCRA closure requirements, they are not specifically required to install leachate collection systems as a condition for unit closure. Nonetheless, where these units are found to be contaminating groundwater, installation of leachate collection systems may be necessary to provide long-term control of unit releases to groundwater. HSWA also imposed severe restrictions on the types of hazardous waste that may be disposed of in landfill units. For example, the Agency has restricted the land disposal of specific hazardous wastes as necessary to protect human health and the environment. In accordance with a schedule mandated by HSWA, EPA currently is reviewing all hazardous wastes for possible land disposal restrictions, and establishing Best Demonstrated Available Technology (BDAT) treatment standards to control the land disposal of hazardous wastes.

Landfills managing nonhazardous wastes currently are regulated under the RCRA Subtitle D program. Subtitle D landfills include municipal/commercial landfills used for the management of municipal refuse, incinerator ash, sewage sludge, and a range of industrial wastes, as well as private industrial landfills used for on-site management of industrial wastes. Current Subtitle D criteria for classification (40 CFR Part 257) state that a landfill is considered to be an open dump if it contaminates an underground drinking water source. However, current regulations do not impose design or operational standards such as leachate collection requirements on the Subtitle D landfills. Nonetheless, as evidenced by existing data on Subtitle D facilities, some of these landfills already have installed leachate collection systems to prevent off-site releases to groundwater.

Under HSWA, EPA must revise Subtitle D criteria that apply to facilities receiving household hazardous wastes or small quantity generator (SQG) wastes by March 31, 1988. These revisions must include groundwater monitoring requirements and corrective action, where appropriate. Imposition of groundwater monitoring and corrective action requirements on these facilities will likely result in increased use of leachate collection systems to control releases to groundwater. EPA also must evaluate other Subtitle D land disposal facilities to determine whether the existing criteria are adequate to protect human health and the environment from groundwater contamination.

Landfills that closed prior to the effective date of the Agency's hazardous waste regulation (October 30, 1980) and nonhazardous waste landfills may be regulated under RCRA Subtitle C corrective action requirements when located at RCRA treatment, storage, and disposal facilities. Under 1984 corrective action amendments, EPA may require corrective action for releases from solid waste management units, including nonhazardous waste landfills that could include collection of leachate and/or groundwater pumping discharges.

3.1.2 Regulation of Hazardous Waste and PCB Incinerators

Hazardous waste incinerator units currently are regulated under RCRA Subtitle C. Technical standards for interim status and RCRA-permitted incinerators are outlined in 40 CFR Part 265, Subpart O and 40 CFR Part 264, Subpart O, respectively. These standards apply equally to on-site incinerators operated by hazardous waste generators, and off-site or commercial incinerators that accept hazardous waste from generators on a commercial basis.

Current RCRA standards for permitted incinerators require 99.99 percent destruction and removal efficiency (DRE) for principal organic hazardous constituents (POHC) and 99.9999 DRE for dioxins and furans in the waste feed to the incinerators. Permitting standards also control incinerator emission rates of hydrogen chloride and particulates. Although RCRA interim status standards do not directly regulate emission rates, many interim status incinerators already are equipped with air pollution control devices to control emission of gases and particulates. Facilities will generate scrubber liquids and sludges that require treatment and disposal when wet systems such as venturi scrubbers are used for the control of incinerator emissions. Because scrubbers may be used to control both gases (i.e., hydrogen chloride) and particulates, in contrast with dry systems such as bag houses, which control only particulates, generation of scrubber wastewaters by hazardous waste incinerators will likely increase as incinerator permitting progresses.

Several ongoing regulatory and programmatic developments are likely to create a shortfall in hazardous waste incineration capacity, and may result in the construction and permitting of new incinerators. For example, the land disposal ban program will curtail land disposal of certain wastes and will require selection of alternative treatment and disposal methods for these wastes. Incineration already has been designated as BDAT for a range of non aqueous solvent wastes, and will likely be defined as BDAT for numerous organic wastes considered in the future.

Also, EPA recently proposed the regulation of Subtitle C industrial boilers and furnaces managing hazardous waste, and is considering the imposition of emission controls on organics, hydrogen chloride, and metals for these units. If these restrictions are promulgated, some industrial facilities may choose to transfer these wastes from boilers and furnace units to on-site or off-site incinerators instead of retrofitting existing boilers or furnaces to comply with new controls. Wastes generated by facility clean-ups undertaken in response to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)/RCRA corrective criteria and state cleanup programs also will increase the demand for hazardous waste incineration capacity. The Agency projects a shortage of incineration capacity as a result of the land disposal restrictions (51 FR 40614).

Disposal of wastes containing polychlorinated biphenyls (PCBs) currently is regulated under the Toxic Substances Control Act (TSCA). Technical standards for PCB disposal, including incineration and burning in boilers and furnaces, are contained in 40 CFR Part 761. In instances where PCBs are constituents of a hazardous waste (e.g., solvents), a permitting official would apply the more stringent of the RCRA or TSCA rules in regulating the incinerator operation.

3.1.3 Regulation of Commercial Aqueous Waste Treatment Facilities

Commercial aqueous waste treatment facilities use numerous physical, chemical, and biological processes (e.g., neutralization, chemical precipitation, and biological treatment) for the treatment of aqueous hazardous waste from off-site generators. Presently, the treatment processes themselves are not directly regulated under RCRA Subtitle C unless the hazardous wastewater treatment operations are conducted in surface impoundments rather than tanks. Surface impoundments are regulated as hazardous waste treatment, storage, and disposal (TSD) units under RCRA Subtitle C, and must comply with stringent technical standards (e.g., liner requirements, groundwater monitoring) designed primarily to prevent the release of waste constituents to groundwater. RCRA technical standards do not, however, regulate effluents discharged from these units to surface waters or POTWs.

RCRA technical standards also may apply to ancillary waste management operations such as storage or other TSD units (i.e., incinerators or landfills) where the aqueous hazardous waste treatment operation is part of an integrated hazardous waste facility. Where a commercial aqueous hazardous waste treatment facility has at least one regulated TSD unit on-site, the facility becomes RCRA-regulated TSDF and accordingly is subject to RCRA corrective action requirements. Under RCRA corrective action, the facility may be required to address releases from regulated TSD units and solid waste management units (SWMUs), including wastewater treatment units, located at the site.

3.2 DISCUSSION OF WQA REQUIREMENTS

3.2.1 Regulation of Direct Discharges to Surface Water

Under the Clean Water Act (CWA), direct discharges to surface waters are controlled through the imposition of effluent limitations contained in NPDES permits issued by authority of CWA Section 402. Effluent limits developed by a permit writer may be based on the following guidelines promulgated by authority of CWA Sections 301 or 306:

- Best practicable control technology currently available (BPT) - intended to provide an initial set of discharge controls on the discharge of conventional pollutants from existing sources.
- Best available technology economically achievable (BAT) - intended to provide additional controls on the discharge of toxic and nonconventional pollutants.
- Best conventional pollutant control technology (BCT) - intended to provide additional controls on the discharge of conventional pollutants (i.e., BOD, TSS, pH, fecal coliform, and oil/grease).
- New source performance standards (NSPS) - intended to provide discharge controls for new sources.

The current framework for control of toxic pollutants is contained in a settlement agreement negotiated in 1976 between EPA and plaintiff environmental groups. This agreement required EPA to develop a program and adhere to a schedule for promulgating BAT effluent guidelines, pretreatment standards (for indirect dischargers), and new source performance standards for 65 pollutants and pollutant classes potentially discharged by 21 major industries [see Natural Resources Defense Council v. Train, 8 ERC 2120 (D.D.C.)]. The basic elements of the NRDC consent decree subsequently were codified in the 1977 CWA amendments.

While addressing most major manufacturing industries, the consent decree currently does not encompass waste management facilities such as landfills, incinerators, and aqueous waste treatment facilities. As a result of longstanding RCRA exemptions for hazardous wastes disposed of and treated in wastewater systems (both direct and indirect) as well as expected additional demands by hazardous waste handlers on the use of wastewater systems due to RCRA regulatory actions and decreased disposal capacity for CERCLA wastes, the Office of Water (OW) is reviewing the need for developing additional wastewater discharge limitations. In part, this OW response is based on Section 3018(b) of RCRA, which requires that the Agency promulgate additional wastewater treatment requirements for indirect dischargers, as the Administrator deems necessary as a result of the findings of the 3018(b) Report to Congress.

The U.S. EPA's "Report to Congress on Hazardous Waste Discharges to Publicly-Owned Treatment Works" determined that POTWs were handling significant quantities of hazardous constituents discharged by categorical industries, improvements to the pretreatment programs would result in enhancing POTW capability to control such discharges, and that further study was necessary, particularly with respect to the rates and effect of those pollutants. The report did not address the quantity, type, fate, and effects of hazardous waste constituents discharged by direct dischargers; however, existing data on the practices of hazardous waste handlers suggest that direct discharge wastewater systems are used for hazardous constituent treatment.

EPA has not yet promulgated effluent guidelines to assist permit writers in formulating NPDES permits for hazardous waste treatment facilities. In the absence of these guidelines, permit writers must rely wholly on their own best professional judgment (BPJ) in setting limits for discharges by these facilities. This process requires a permit writer to make complex, site-specific determinations, often evaluating factors such as wastewater characteristics, pollutant concentrations, available pollution control technologies, and water quality constraints.

New source performance standards (NSPS) may have particular importance for the HWT industrial sector, due to increasing restrictions on certain waste management practices (e.g., land disposal). Some industrial facilities may choose to send wastes off-site to commercial facilities in lieu of pursuing on-site management options. These trends will increase the demand for commercial treatment and disposal capacity, and result in the siting and construction of new commercial facilities. Applicable discharge controls are likely to represent a key consideration in the design and construction of these facilities.

Wastewaters generated by on-site hazardous waste treatment units such as landfills and incinerators are not addressed specifically by effluent guidelines for specific industrial categories covered by the NRDC consent decree. For example, effluent guidelines do not establish process-specific limits for scrubber wastewaters from on-site hazardous waste incinerators or leachate from on-site industrial landfills. Existing permit limits may not offer adequate control in instances where hazardous residuals contain different pollutants (e.g., dioxins, furans) or pollutants in greater concentrations than other plant wastewaters. Again, where effluent guidelines do not specifically cover a certain wastewater generated by an individual facility, the permit writer must exercise BPJ in developing appropriate limits for these waste streams. Nonetheless, where pollutants contained in these wastewaters are identified as similar to pollutants contained in other regulated waste streams, the NPDES permit limits should provide some control of constituents contained in residuals from hazardous waste treatment units.

3.2.2 Regulation of Indirect Discharges to Publicly-Owned Treatment Works

Under the CWA, discharges to Publicly-Owned Treatment Works (POTWs) are controlled through the imposition of pretreatment standards promulgated by authority of CWA Section 307. These standards apply to wastewater discharged by an industrial facility to a POTW collection system. Certain types of pretreatment standards, referred to as national categorical standards, apply uniformly to all facilities determined to be within the scope of the regulated industrial category. Categorical standards include:

- Pretreatment standards for existing sources (PSES) - intended to pro vide controls on pollutant discharges by existing sources.

- Pretreatment standards for new sources (PSNS) - intended to provide controls on pollutant discharges by new sources.

As mandated by the NRDC consent decree and 1977 CWA amendments, EPA is required to promulgate categorical pretreatment standards for the 21 major industries enumerated in the consent decree.

General prohibitions prevent the discharge of pollutants that interfere with POTW treatment processes or pass through the POTW, causing water quality violations. Other specific prohibitions forbid discharge of flammable materials, corrosive wastes, and other harmful wastewaters. Moreover, designated POTWs are required to develop local limits necessary to implement these prohibitions and protect the POTW from interference and pass-through. For establishing these limits, the POTW must determine the maximum pollutant quantity that the system is capable of handling, and then allocate this quantity among industrial users potentially discharging the pollutant.

3.3 INDUSTRY GROWTH POTENTIAL

As indicated in Section 3.1, current RCRA regulations are expected to increase the number of leachate collection systems; and consequently, the volumes of leachate requiring treatment and disposal. Because of the large number of Subtitle D landfills compared to Subtitle C landfills, most future sources of leachate are expected to come from municipal landfills. Since most Subtitle D landfills are believed to be indirect dischargers, as discussed in Section 3, this implies that POTWs will be receiving the majority of the leachate and could potentially be severely impacted.

Use of wet scrubbers is becoming the industry standard and future incinerators involved in facility cleanup in response to CERCLA/RCRA corrective criteria and state cleanup programs will generate scrubber wastewaters for treatment. While the increase in the amount of scrubber wastewater is expected to be small compared to the amount of leachate that potentially could be collected, the load of toxic pollutants in these wastewaters could have a significant impact on the Nation's waters and POTWs.

Finally, the impacts of RCRA on other hazardous waste management practices particularly land disposal bans and BDAT requirements, may force more generators to dispose of their wastes at commercial aqueous hazardous waste treaters. Industry growth could stem also from practices such as the collection of more leachate, closure of surface impoundments, and cleanup at CERCLA sites.

Another potential impact on the HWT industry due to RCRA is the pending air emission regulations for TSDFs. RCRA regulations for TSDFs, currently under development, will reduce air emissions from hazardous waste TSD processes. Control techniques may result in increased organic concentrations in wastewaters and/or additional waste streams.

4. HWT INDUSTRY PROFILE

The hazardous waste treatment (HWT) industry includes those facilities that generate and discharge wastewaters to surface waters or Publicly-Owned Treatment Works (POTWs) as a result of RCRA-regulated activities involving the storage, treatment, or disposal of toxic wastes. This industry can produce wastewaters by the following methods:

- Treatment and discharge of aqueous liquid hazardous wastes.
- Discharge of air pollution scrubber wastewaters from incinerator operations.
- Leachates from landfills. For the purpose of this study, the term leachate refers to all landfill aqueous discharges.

As discussed in Chapter 3, the discharge of these wastewaters to surface waters and POTWs is not regulated by RCRA, nor is it covered by other categorical standards.

Although the HWT industry has been studied extensively for its management of hazardous wastes, there are limited data on the generation and disposal of wastewaters from these facilities. EPA has not yet undertaken a detailed and comprehensive study of the wastewater generated by the HWT industry; therefore, a definitive profile of this industry is not available. However, current data bases and the literature have been reviewed and evaluated; a telephone verification of information supplied by TSDFs to EPA under authority of RCRA was undertaken for a small segment of the industry; and EPA regional and State environmental files were reviewed to help to profile this industry. This effort has resulted in a preliminary profile, which is presented in this Section and includes:

- The types of facilities and their operations
- The number of facilities
- The geographic distribution of the industry
- Their methods of discharge.

4.1 DEFINITION OF THE HWT INDUSTRY

For the purpose of this study, the HWT industry is defined as follows:

- Commercial HWT facilities, including commercial incinerators, landfills, and aqueous treaters
- Incinerators at on-site generators that discharge scrubber wastewater
- Landfills at on-site generators that collect and dispose of leachate
- Municipal landfills that collect and dispose of leachate
- Subtitle D landfills that collect and dispose of leachate
- On-site generators not regulated by categorical standards that discharge wastewater associated with their TSD operations.

As a result of this definition, the HWT industry consists primarily of noncategorical facilities (e.g., facilities not currently regulated by categorical discharge standards); however, a number of facilities regulated by categorical discharge standards are also commercial HWT facilities, and therefore are included in this definition. An example of such a facility is the DuPont Deepwater, New Jersey facility, which is an organic chemicals manufacturing plant (OCPSF category) that accepts aqueous hazardous waste from the entire United States for comingling and treatment.

Noncategorical on-site generators are an ill-defined group of facilities. Included in this grouping are Paragraph 8 industries and Federal facilities such as Army depots and Department of Energy government owned and contractor operated (GOCO) facilities. Although included in the HWT industry, the data available for noncategorical on-site generators are limited.

4.2 DESCRIPTION OF THE HWT INDUSTRY

The HWT industry can be divided into three major subcategories for the purpose of this study:

- Leachate treatment facilities - provide collection and treatment of aqueous discharge from on-site, commercial, municipal, private, hazardous waste, industrial, and/or Subtitle D landfills. These discharges can include leachate collected at the bottom of the landfill and any groundwater removed from the water table.

- Incinerator scrubber wastewater treatment facilities - limited to those facilities treating only incinerator scrubber wastewater or on-site generators of incinerator scrubber wastewater that combine the incinerator scrubber wastes with other wastewaters for treatment.

- Aqueous hazardous waste treatment facilities - provide physical, chemical, and/or biological treatment of hazardous and nonhazardous wastewaters, including leachate from on-site and off-site landfills and process wastewaters from on-site and off-site manufacturing operations. Whereas leachate treatment facilities only handle on-site generated wastewaters, commercial aqueous treaters handle a variety of wastewaters, including leachate.

4.2.1 Landfills and Leachate Collection and Treatment

Landfills commonly are described by the types of wastes that they accept or by their design. Some of the terms used to describe types of landfills are municipal, sanitary, chemical, industrial, secure, RCRA, hazardous waste, Subtitle C, and Subtitle D. Although municipal landfills do not knowingly accept hazardous wastes, they can contain these wastes due to disposal practices that occurred prior to RCRA. The HWT industry includes all landfills that discharge leachate.

As a result of past design practices, most Subtitle D landfills do not have leachate collection systems or liners. These landfills were designed with the intent of using the natural soils and groundwater flow system to attenuate the leachate generated by the wastes. The difficulty in finding appropriate sites and the growing concern that the contaminant loadings generated exceeded the attenuative capacity of even the most suitable sites led to the concept of containment designs. Containment landfills have clay or synthetic liners along with leachate collection systems. Depending on the design of the landfill, higher groundwater flows into the site may result in higher leachate generation rates.

Most Subtitle C landfills that retained interim status after November 7, 1985, have liners and leachate collection; however, only new landfills and expansions and replacements of interim status landfills are required to have a double liner with leachate collection under the 1984 Hazardous and Solid Waste Amendments (HSWA) to RCRA. Loss of Interim Status (LOIS) landfills continue to generate leachate, although they no longer accept wastes and are undergoing closure.

As a result of past practices and regulations (both RCRA and state), leachate collection is limited to a small percentage of the landfills existing in the United States. Current design practices and regulations have resulted in the installation of liners and leachate collection systems in the new cells as they are opened at Subtitle C landfills. The result is an increasing volume of leachate that requires treatment and disposal.

Subtitle C and some Subtitle D landfills presently screen incoming wastes. Screening can range from spot checks of municipal refuse trucks to extensive sampling and quality assurance (QA) procedures, which can result in the barring of trucks carrying banned wastes. Screening by Subtitle D facilities is important, since RCRA regulations require that Subtitle D facilities only accept nonhazardous wastes. A list of excluded wastes often is posted at Subtitle D facilities and is provided to regular users of the facility.

Subtitle C facilities are required to obtain a detailed physical and chemical analysis of a representative sample of wastes accepted for burial. In addition, RCRA prohibits the landfilling of bulk or noncontainerized liquids, nonhazardous liquids in Subtitle C landfills and liquids adsorbed in materials that biodegrade or release liquids when compressed, and some solvents. These prohibitions are fairly recent (since 1984, and in some cases November 1986), and consequently, existing hazardous waste (Subtitle C) landfills contain the prohibited wastes, having accepted these wastes in the past.

4.2.2 Incinerators and Scrubber Wastewater

The most common type of incinerator in hazardous waste service is liquid injection, representing 64 percent of the incinerators in 1981. Liquid injection incinerators can burn only liquid wastes. The next most common types of incinerators are the fixed hearth and the rotary kiln. Both of these will dispose of solids and/or liquid wastes, including containerized wastes and drums. RCRA regulations require that permitted hazardous waste incinerators achieve 99.99 percent destruction for each principal organic hazardous constituent designated in the facility's permit for each waste feed. Incinerators permitted to burn dioxins and furans are required to achieve 99.9999 percent destruction. Incinerators burning polychlorinated biphenyls (PCBs) are regulated under the Toxic Substances Control Act (TSCA), not RCRA. Interim status facilities are not required to meet any performance standards.

RCRA requires that permitted hazardous waste incinerators control hydrogen chloride gas (HCl) and particulates in their stack emissions. Most facilities, including those with interim status, are equipped with at least one air pollution control device. These devices include venturi scrubbers, ionizing wet scrubbers, baghouses, and electrostatic precipitators. The venturi and ionizing wet scrubbers remove both gases and particulates, generating scrubber wastewaters for treatment and disposal; the baghouses, which are dry, remove only particulates. Electrostatic precipitators can be either wet or dry.

Commercial hazardous waste incineration facilities screen the wastes that they accept to ensure compliance with their interim status RCRA or final RCRA permit requirements. Screening procedures include analyses of representative waste samples, spot checks of incoming shipments, or bans on specific waste types. For example, only TSCA incinerators will accept PCB-containing wastes. Some facilities also refuse to accept certain wastes because of limitations in their air emissions permit or local limits in their wastewater (pretreatment) permit.

Presently, there are less than six incinerators that are permitted by TSCA to burn PCB-containing wastes. It is believed that only a few years remain in the PCB incineration market due to declining generation of PCB liquids and the preferred method of chemical destruction of these wastes rather than incineration. PCB incinerators then will be used to destroy other RCRA wastes or PCB-contaminated solids.

4.2.3 Aqueous Hazardous Waste Treaters

Aqueous hazardous waste treaters provide treatment of wastewaters containing high concentrations of toxic or hazardous pollutants. Aqueous treaters include both on-site generators that are not regulated by categorical discharge standards but treat process wastewater, and commercial hazardous waste treaters. Commercial treaters provide a service to other facilities that cannot provide treatment on-site. Facilities that transport wastes to commercial aqueous hazardous waste treaters include:

- Landfills that choose not to provide treatment on-site or do not have an acceptable receiving stream or sewer line available
- On-site operators who find it more cost-effective to contract haul their waste to a commercial facility.

Commercial hazardous waste treaters differ from centralized treatment systems in that centralized treatment facilities are designed to treat one type of waste, and usually only accept waste from a fixed number of clients. For example, a number of electroplaters in one community may use one central treatment facility for treatment of their common wastewaters. Commercial aqueous hazardous waste treaters handle a range of hazardous wastes and will accept any wastes that pass their screening procedures.

Treatment provided at the commercial waste treaters may include pretreatment of specific waste types (e.g., cyanide destruction), physical/chemical treatment, biological treatment, and tertiary treatment. The attraction of aqueous hazardous waste treatment is that the treated effluent is excluded from RCRA regulations, which only regulate the storage and handling of the wastes before and during treatment [40 CFR 261.4(a)(2)]. No RCRA performance standards exist for these treatment systems, although the final effluent must meet either National Pollution Discharge Elimination System (NPDES) permit limitations or pretreatment standards. Wastes treated by these facilities include:

- Pesticides
- Plating baths
- Cyanides
- Flammable wastes
- Acidic wastes
- Caustics
- Oily wastes
- Commercial chemical products
- Leachate from hazardous waste landfills
- PCBs
- Paints and inks
- Metal bearing wastes
- Halogenated organics
- Nonhalogenated organics
- Reactives
- Halogenated solvents
- Nonhalogenated solvents

Commercial aqueous hazardous waste treaters also are required to screen the wastes that they receive. RCRA regulations require a chemical/physical analysis of a representative sample. In addition, some commercial facilities limit the types of waste that they will accept for treatment due to restrictions in their operating permit, limitations in the capabilities of their treatment systems, and/or effluent limitations in their NPDES or pretreatment permits.

4.2.4 Integrated Facilities

The HWT industry includes a number of large, complex facilities that offer a variety of hazardous waste management services at a single facility. These facilities can include an incinerator, an aqueous treatment system, and a landfill. Although presently there are only a few of these integrated facilities, a survey of the RCRA Part B applications indicated that a large number of the commercial facilities are planning to expand into integrated facilities by offering additional services at existing sites.

Currently, many commercial facilities serve as brokers for their customers. That is, a commercial facility will accept wastes from a customer even though it is unable to treat it at its own facility. However, the commercial facility will arrange to have the waste treated at another commercial facility. In this way, a generator does not have to search for and ship each unique waste to a different commercial facility.

4.3 NUMBER OF HWT FACILITIES

The following sections present estimates of the number of HWT facilities by subcategory. The estimates reflect data gathered from numerous sources, which have been used to develop a best estimate of the number of facilities in each subcategory.

4.3.1 Landfills

Table 4-1 presents an estimate of the number of hazardous waste and Subtitle D landfills in the United States using data collected from numerous sources. The Office of Solid Wastes (OSW) February 1987 report lists 49 commercial hazardous waste landfills, which corresponds closely to a 1985 publication (Ref. 8) that includes 43 facilities. The OSW count includes one facility whose permit was denied. While both of these sources report only active landfills, the Hazardous Waste Data Management System (HWDMS) data base includes landfills undergoing closure. The February 1987 OSW report listed 18 landfills undergoing closure, including 11 that have not submitted a closure plan. The remaining discrepancy between HWDMS and the OSW counts is probably due to the fact that HWDMS includes five or six protective filers and a few landfills that subsequently have been reclassified as waste piles or surface impoundments.

Environmental Information's (E.I.'s) Directory contains 34 landfills, which is the smallest number of commercial hazardous waste landfills. This directory is a sourcebook for generators in search of a commercial firm to serve their needs. Commercial facilities are listed in the directory based on response to a questionnaire distributed by E.I.

For the purpose of this analysis, the number of commercial hazardous waste landfills was estimated to be 67. This number represents the sum of the active (49) and closure (18) facilities taken from OSW's report. Facilities undergoing closure were included in the estimate because leachate generation does not necessarily cease with the closure of a site.

The HWDMS data base estimates 155 hazardous waste landfills at categorical generators and an additional 146 landfills at generators not regulated by categorical discharge standards. The 146 includes 15 municipal waste landfills. EPA data indicated that approximately 20 percent of the active TSD facilities in the HWDMS data base lost interim status and were required to close by November 8, 1985. Since the breakdown of these facilities with and without leachate collection systems is not available, it was assumed that the loss of interim status (LOIS) facilities do not have leachate collection; therefore, the number of hazardous waste landfills at on-site generators with leachate collection as required by RCRA was estimated at 240 (e.g., 80 percent of 301).

TABLE 4-1. ESTIMATE OF THE NUMBER OF HAZARDOUS WASTE AND SUBTITLE D LANDFILLS

	Estimated Number of HW Landfills			
	Commercial Facilities	Noncommercial* Facilities	Categorical Industries	Total
OSW Report on RCRA Permit Activities[a]	49	--	--	--
"Hazardous Waste Consultant" List[b]	43	--	--	--
E.I.'s Directory of Industrial and Hazardous Waste Management Firms[c]	34	--	--	--
HWDMS Data Base	75	146	155	376

* Other than commercial facilities

[a] Reference 1

[b] Reference 2

[c] Reference 3

Source of Data	Estimated Number of Subtitle D Landfills
Active Subtitle D Landfills[d]	16,416
Municipal Waste	9,284
Industrial Waste	3,511
Demolition Debris	2,591
Other	1,030

[d] Reference 4

All of these facilities are expected to have leachate collection systems, resulting in wastewater discharge.

OSW's Subtitle D Study Phase I report estimated that there were 16,416 active Subtitle D landfills in 1984. Of these, 57 percent are municipal, 21 percent were industrial, and 16 percent were demolition debris landfills. The report also concluded that 53 percent of all municipal landfills receive small quantity generator (SQG) hazardous wastes.

In this EPA-ITD study, only landfills with leachate collection or groundwater recovery are considered part of the industry. Therefore, an estimate of the number of facilities that discharge leachate is necessary. Table 4-2 presents such an estimate. This table shows that of the 16,416 Subtitle D landfills, only 604 had leachate collection, while 4,927 rely on the underlying soils to provide leachate treatment. Approximately half of the 604 leachate collection systems provide treatment for the discharge.

Method of Discharge

Table 4-3 presents a summary of the available data regarding the treatment and disposal of leachate. The table includes data from both hazardous waste and Subtitle D facilities. These results do not represent an unbiased, independent survey of landfills and should not be interpreted as such. The data were collected as part of an effort to locate potential sampling candidates, and therefore may be biased toward leachate collection and treatment. However, based on this information, a preliminary breakdown of the leachate subcategory, by discharge type, is 19 percent direct, 40 percent indirect, and 41 percent other dischargers. Most facilities in the other category claimed to be zero dischargers, however, it is anticipated that most of these facilities will have occasional discharges due to maintenance, shutdowns, etc.. Applying these percentages to the estimated number of landfills with leachate systems (911, see Table 4-8), results in 173 direct dischargers, 355 indirect dischargers and 383 other.

Discharge to a POTW appeared to be the most common leachate treatment/disposal method, which is a reflection of several factors. First, municipalities tend to send leachate from their landfills to their POTW rather than incur the expense of either constructing and operating a leachate treatment plant at the landfill or opting for some other disposal method. Leachates either are trucked or sewered to the POTW. In most cases, the leachate volume represents a small fraction of the flow to the POTW. Privately operated Subtitle D landfills also tend to use POTWs, since they provide convenient and relatively inexpensive leachate treatment/disposal. In addition, some commercial landfills (both hazardous waste and Subtitle D) provide on-site leachate treatment, but discharge the treated leachate to a POTW.

TABLE 4-2. LEACHATE MANAGEMENT AT SUBTITLE D LANDFILLS

Landfill Type	(1)	Leachate Collection Systems	Leachate Treatment Systems	Leachate Recirculation
Municipal	3,677	481	245	205
Industrial	657	112	69	27
Demolition Debris	541	5	1	0
Other	52	6	2	0
Total	4,927	604	317	232

Source: Reference 5

NOTE:

(1) Landfills that do not have leachate collection systems or liners.

TABLE 4-3. LEACHATE TREATMENT/DISPOSAL PRACTICES - SUMMARY OF AVAILABLE DATA

Leachate Disposal Practice	Number of Facilities Supplying Data*
Discharge to NPDES Outfall	19
Discharge to POTW	39
Solidify and Rebury	6
Off-site Disposal at a Commercial Treater	14
Deep Well Injection	7
Surface Impoundment	7
Incineration	2
Land Application	1
No Leachate Generated	3
Total	98

* Includes both hazardous waste and Subtitle D landfills

Sources:

1) SAIC verification study
2) SAIC 1986 and 1987 sampling efforts
3) Data from state agencies
4) Reference 6
5) Reference 7

This arrangement may reflect limited on-site treatment technologies, liability considerations, permitting and regulatory issues, or the location of the landfills near a sewered metropolitan area.

The second most common disposal practice appeared to be direct discharge through an NPDES outfall, followed closely by off-site disposal at a commercial treater. Both hazardous waste and Subtitle D landfills located in unsewered areas most frequently discharge to surface waters, although they might truck their effluent to a POTW for treatment.

Contract hauling of leachate to commercial aqueous waste treaters is also a common practice at hazardous waste landfills. In addition, several hazardous waste landfills have become commercial aqueous hazardous waste treaters. These landfills have taken advantage of their extensive leachate treatment systems by accepting off-site-generated aqueous hazardous wastes for treatment in their facility along with their leachate.

Solidification and reburial is a practice used by several facilities. This option is popular when leachate volumes are small. Deep well injection was common among landfills in Alabama, Texas, Oklahoma, and Louisiana. Landfills in the arid West either do not generate leachate or use surface impoundment (i.e., evaporation) for the disposal of the small volumes of leachate generated.

In summary, the size of the leachate subcategory was estimated at 911 facilities. This included all of the commercial hazardous waste landfills (67) plus the Subtitle D and hazardous waste landfills with leachate collection systems (604 and 240, respectively).

4.3.2 Incinerators and Scrubbers

Table 4-4 presents estimates of the number of hazardous waste incinerators. The data in the table have been compiled from several sources. Both the HWDMS data base and EPA's directory estimated the number of commercial hazardous waste incinerators to be 42. E.I.'s directory includes 40 commercial incinerators.

Three sources provided estimates of the total number of incinerators that burn hazardous waste. The HWDMS data base estimated this number at 376, which included 164 at categorical industries and 170 at noncategorical facilities (not including commercial industries). Mitre Corporation's survey of incinerator manufacturers reported a total of 342 incinerators sold for hazardous waste use since 1969, or 34 less than the HWDMS. Units sold prior to 1969 may account for the difference between the HWDMS and Mitre estimates.

TABLE 4-4. ESTIMATE OF THE NUMBER OF HAZARDOUS WASTE INCINERATORS

	Estimated Number			
Source of Data	Commercial Facilities	Noncategorical* Facilities	Categorical Industries	Total
OSW Report on RCRA Permit Activities[a]	--	--	--	230
EPA's Directory of Commercial Facilities[b]	42	--	--	--
Mitre Corporation Survey of Manufacturers[c]	--	--	--	342
HWDMS Data base	42	170	164	376
E.I.'s Directory of Industrial and Hazardous Waste Management Firms[d]	40	--	--	--
Average				316

* Does not include commercial facilities

[a] Reference 1

[b] Reference 8

[c] Reference 9

[d] Reference 3

OSW's February 1987 report estimated the total number of hazardous waste incinerators at 230, which is considerably below the other estimates. Part of the discrepancy may be due to reclassification of many of these incinerators as boilers and industrial furnaces. As boilers and industrial furnaces, the facilities are no longer TSDFs and are not subject to RCRA permit and interim status regulations, even though they may be burning hazardous wastes.

For the purpose of this study, the number of incinerators was estimated to be 316, which is the average of the three estimates shown in Table 4-4.

Method of Discharge

Mitre Corporation's survey indicated that all incinerators in hazardous waste service have been equipped with at least one air pollution control device. Table 4-5 presents a summary of available data showing the treatment/disposal of the scrubber wastewaters. This table presents data only for known facilities and cannot be considered as a cross-section of the industry. The data in Table 4-5 indicate that the majority of the incinerators have wet scrubbers. This is expected, since RCRA-permitted incinerators are required to control stack emissions of hydrogen chloride gas, necessitating the use of a wet scrubber. Table 4-5 also shows that the majority (50 percent) of scrubber wastewaters are discharged to surface waters. This occurs because a relatively large number of hazardous waste incinerators are located at facilities that discharge wastewater generated from process sources. These facilities comingle the scrubber wastewaters with their process wastewaters in their on-site treatment systems, resulting in discharge of the scrubber wastewaters through NPDES outfalls. The large commercial incinerators treat their scrubber wastewaters in a dedicated treatment system prior to discharge to a POTW or NPDES outfall, depending on the location of the facility. Only incinerators with small volumes of scrubber wastewater are expected to use off-site treatment/disposal methods. Of the four facilities reporting no scrubber wastewater, two have baghouses and the remaining two report that they have no air pollution control system in-place. Based on the information presented in Table 4-5, the breakdown of the scrubber subcategory by discharge method is estimated to be 137 direct dischargers, 27 indirect dischargers and 109 other dischargers.

RCRA regulations required wet scrubbers for only the 230 facilities that are in the process of obtaining RCRA permits. Other incinerators, probably reclassified as boilers or industrial furnaces, may or may not have wet scrubbers. No data are available for these incinerators. Therefore, the number of incinerators generating scrubber wastewaters ranged from a minimum of 230 to a maximum of 316 (i.e., the estimate of the total number of

TABLE 4-5. MANAGEMENT OF INCINERATOR SCRUBBER WASTEWATER - SUMMARY OF AVAILABLE DATA

Scrubber Wastewater Disposal Method	Number of Facilities Supplying Data
Discharge to NPDES Outfall*	10
Discharge to POTWs	2
Off-site Disposal at a Commercial Treater	2
Landfill	2
Surface Impoundment/Evaporation	1
No Scrubber Wastewater	4

* Includes incinerators at on-site generators that combine scrubber wastewater with process wastewaters for treatment and discharge

Sources:

1) SAIC verification study
2) SAIC 1986 and 1987 sampling efforts

incinerators burning hazardous wastes). Averaging the two numbers (230 and 316) produces an estimate of 273 facilities generating scrubber wastewaters.

4.3.3 Aqueous Hazardous Waste Treaters

Estimates of the number of aqueous hazardous waste treaters are presented in Table 4-6. The HWDMS data base estimates that there are 154 commercial aqueous treaters. In the foreword to its 1987 directory, E.I. indicated that over 150 firms were deleted from its 1986 edition in compiling the 1987 version as a result of closure or nonresponse to E.I.'s inquiries. At the same time, other facilities were added. This suggests that the HWDMS data base and EPA Directory, dated 1985 and 1986, respectively, estimates may be outdated. The 1986 National Survey that used HWDMS for its mailing list may have resulted in the elimination of some commercial firms due to closure, but may not have added newer firms, resulting in an underestimate of the commercial aqueous hazardous waste treatment facilities.

For the purpose of this study, an average of all four data bases has been used to estimate the size of the industry. This resulted in a total count of 125 for commercial aqueous hazardous waste treatment facilities.

Only HWDMS and the 1986 National Survey provided estimates of the noncategorical aqueous hazardous waste treaters. The two estimates, 913 and 280 facilities, respectively, are vastly different. An average of the two values provided an estimate of approximately 600 noncategorical facilities treating aqueous hazardous wastes.

Method of Discharge

Table 4-7 summarizes the available data regarding the fate of aqueous hazardous wastes. The data were collected as part of an effort to locate potential sampling candidates and therefore may be biased toward treatment and discharge. Based on these data, the breakdown of the aqueous treater subcategory by discharge method was estimated to be 86 direct dischargers, 515 indirect dischargers and 124 other dischargers.

Discharge to a POTW was the most common aqueous hazardous waste disposal method. The prevalence of this method was a function of location; most POTWs are located in metropolitan areas near the industries that they serve. Other facilities serving large regions of the country are located near convenient transportation routes that may or may not be in metropolitan sewered areas, resulting in some discharging through NPDES outfalls.

TABLE 4-6. ESTIMATES OF THE NUMBER OF AQUEOUS HAZARDOUS WASTE TREATERS

	Estimated Number			
	Commercial Facilities	Noncategorical* Facilities	Categorical Industries	Total
EPA's Directory of Commercial Facilities[a]	134	--	--	--
E.I.'s Directory of Industrial and Hazardous Waste Management Firms[b]	120	--	--	--
HWDMS Data base	154	913	--	--
1986 National Survey of HW Wastewater Treatment Facilities[c]	91	280	--	1023
Average	125	597		

* Other than commercial facilities

[a] Reference 8

[b] Reference 3

[c] Reference 10

TABLE 4-7. DISPOSAL OF WASTEWATERS BY FACILITIES MANAGING AQUEOUS HAZARDOUS WASTES - SUMMARY OF AVAILABLE DATA

Wastewater Disposal Method	Number of Facilities Supplying Data
Discharge to NPDES Outfall	5
Discharge to POTW	30
Off-site Disposal at a Commercial Facility	3
Deep Well Injection	2
Incineration	1
Off-site Disposal at a Landfill	1

Sources:

1) SAIC verification study
2) SAIC 1986 and 1987 sampling efforts
3) USEPA, ORD, HWERL reports
4) Published literature
5) Data from state agencies

4.4 GEOGRAPHIC DISTRIBUTION OF THE HWT INDUSTRY

EPA Regions V and VI have the largest number of hazardous waste landfills and incinerators; Texas has the largest number of these facilities. Among the Subtitle D landfills, West Virginia, Pennsylvania, and Texas had the largest number, with approximately 1,200 in each state. Texas also had the largest number of Subtitle D municipal landfills, followed closely by Wisconsin. These two states each accounted for 10 percent of the total. Pennsylvania had by far the largest number of Subtitle D industrial landfills, accounting for 30 percent of the total as reported by an EPA study (Ref. 4).

EPA Region V also had the largest number of hazardous waste incinerators; Texas has the largest number of these facilities.

In addition, EPA Region V has the largest number of aqueous waste treatment facilities. Region III is a distant second. A large number of categorical industries were treating on-site-generated aqueous hazardous waste. Assuming that the industries have not constructed dedicated hazardous waste treatment systems, the aqueous hazardous wastes were comingled and treated with the process wastewater at these facilities. The categorical industries (OCPSF, inorganic chemicals, metal finishing, petroleum refining, and electrical and electronic components) reported the largest numbers of facilities treating aqueous hazardous wastes.

4.5 HWT INDUSTRY SIZE ESTIMATE SUMMARY

Estimates of the number of facilities potentially included in the HWT industry are summarized in Table 4-8. The table presents the estimates by subcategory and type of facility for each subcategory. The industry size was estimated at facilities based on currently available data. The future size of this industry will be affected by current and proposed RCRA regulations.

4.6 FINANCIAL CHARACTERISTICS OF COMMERCIAL FACILITIES

EPA has collected financial data on some firms operating commercial hazardous waste treatment and disposal facilities. These data allow the calculation of financial ratios to provide a picture of some financial characteristics of the industry. The data available for the ratio calculation are: net income, cash flow, net worth and total assets. Two financial ratios are presented in Table 4-9: net income to total assets and cash flow to total assets. As shown on the upper part of the table, the average of the net income to total assets is 8.9 percent for publicly-owned firms and 5.1 percent for privately held firms. Similarly, the average of the cash flow to total assets ratio is 13.4 percent and 11.4 percent for public and private firms,

TABLE 4-8. HAZARDOUS WASTE TREATMENT INDUSTRY PROFILE

Number of Facilities

Subcategory Name	Total	Facility Prod. Waste Water	Direct Discharger	Discharge to POTW	Handled by Hauling	Other Discharge
Landfills						
Commerical	67	67				
Non-commercial	301	240				
Subtitle D Landfill	16,416	604				
Total	16,784	911	173	355	128	255
			19%	39%	14%	28%
Incinerators						
Comercial	42					
Non-commercial	274					
Total	316	273	137	27	27	82
			50%	10%	10%	30%
Aqueous waste treaters						
Commerical	125	125				
Non-commerical	600	600				
Total	725	725	87	515	51	72
			12%	71%	7%	10%

TABLE 4-9. STATISTICS OF SELECTED FINANCIAL RATIOS FOR THE HWT INDUSTRY

Finanical Ratio	Net Income/Total Assets (%)		Cashflow/Total Assets (%)	
	Public	Private	Public	Private
No. of Firms in Sample	10	230	10	177
Average	8.9	5.1	13.4	11.4
Minimum	2.0	-20.6	3.1	-9.7
Maximum	17.1	51.2	17.1	71.6
Standard Deviation	4.6	5.6	6.4	10.4

Statistics of Complete Sample (Public - Private)

Finanical Ratio	Net Income/Total Assets (%)	Cashflow/Total Assets (%)
No. of Firms in Sample	240	187
Average	5.3	11.5
Minimum	-20.6	-9.7
Maximum	51.2	71.6
Standard Deviation	5.7	9.5

respectively. These estimates inherit considerable dispersion shown by wide range of values and large standard deviation, thus the average ratios of the public firms cannot be shown to be statistically different from those of private firms. The lower part of the table presents the calculated ratios for the entire sample with the public and private firms.

A smaller group of 18 firms has been selected by EPA to be surveyed annually as commercial hazardous waste treatment firms (Ref. 11). This group is the best representation of firms whose major business is the treatment and disposal of hazardous waste. Financial data are available for 14 of the 18 firms. Financial ratios for these firms have been calculated and are presented in Table 4-10. The average ratios appear to be higher than those of Table 4-9, but again the differences are not statistically significant.

4.7 COMMERCIAL HAZARDOUS WASTE MANAGEMENT PRICE

Table 4-11 presents the range of service prices for several waste management technologies. The general ranking of fees of the treatment and disposal processes are, from high to low: incineration; chemical treatment (aqueous treatment); hazardous waste landfill; and municipal landfill. However, within each type of treatment or disposal, prices vary considerably in relation to waste composition, form of the waste, and so on. In 1985, incineration costs ranges from $0.10-4.17 per gallon for typical liquids, and in the range of $2.10-8.30 per gallon for highly toxic liquids. The low end of the range was for liquids with a high BTU content, which helps in the incineration process. Chemical treatment cost ranged from $0.12 to $6.00 per gallon, with relatively low fees for acid/alkaline wastes and high fees for highly toxic wastes. Hazardous waste landfill charges ranged from $69-140/ton ($0.29 to 0.58 per gallon) for bulk waste, and $50-137 per drum ($0.91 to 2.50 per gallon) for containerized waste. Municipal landfill fees range from $2.05 to 37.37/ton. All prices have increased between 1983 and 1985, with incinerator and chemical treatment having the largest percentage increases, and deep well injection having the smallest increase. With the short supply of incinerator capacity, these price increases are likely to continue.

4.8 SUMMARY

- The HWT industry was divided into three subcategories:
    - Landfills with leachate collection and treatment facilities

- Incinerators with scrubber wastewaters
- Aqueous hazardous waste treaters.

- The number of facilities in each subcategory was estimated as follows:

Subcategory	Number of Facilities
Landfills with leachate systems	911
Incinerators with scrubber wastewaters	273
Aqueous hazardous waste treaters	725

- The most common method of wastewater disposal for the landfill and aqueous hazardous waste treaters subcategories is to POTWs. Incinerators with scrubbers are more commonly direct dischargers. The breakdown by discharge method of each subcategory was estimated as follows:

	Number of Facilities		
	Direct	Indirect	Other
Leachate	173	355	383
Wet Scrubber	137	27	109
Aqueous Treaters	87	515	123

Other dischargers include deep well injection, incineration, off-site disposal, land application, and solidification and burial.

- EPA Regions V and VI have the largest number of hazardous waste landfills and incinerators. The largest number of aqueous waste treatment facilities is in EPA Region V.

TABLE 4-10. STATISTICS OF SELECTED FINANCIAL RATIOS FOR THE SELECTED FIRMS IN THE HWT INDUSTRY

Financial Ratio	Net Income/Total Assets (%)	Cash flow/Total Assets (%)
No. of Firms in Sample	14	13
Average	7.6	18.0
Minimum	2.0	11.4
Maximum	17.1	23.3
Standard Deviation	4.3	4.1

Source: Ref. 11

TABLE 4-11. COMPARISON OF HAZARDOUS WASTE MANAGEMENT PRICES (PER GALLON) QUOTED BY ALL FIRMS IN 1983, AND 1985 a/

Waste Management Technology	Type or Form of Waste	Price ($ per gallon unless otherwise indicated) 1983	1984	1985	Percentage change in 1986 relative to 1985
Landfill	o 55-gallon drum	25-60/drum	25-100/drum	50-137/drum	*10-25%
	o Bulk	25-90/ton	40-150/ton	69-140/ton	*10-20%
Land Treatment/Solar Evaporation	All	0.02-0.09	0.02-0.09	0.33-0.83	*15%
Incineration	o Clean liquids, high Btu value	(0.05)c/-0.25	(0.05)c/-0.35	0.10-1.93	*15-50%
	o Liquids, low Btu	0.35-1.00	0.30-1.25	1.33-4.17	*15-50%
	o Sludges and solids			2.75-4.25	*15-50%
	o Highly toxic liquids	1.50-3.10	1.30-4.20	2.10-8.30	*15-20%
	o PCB liquids			2.50-3.50	
	o PCB solids			4.50-12.50	
Chemical Treatment	o Acids/alkalines	0.06-0.55	0.06-0.85	0.12-2.00	*10-20%
	o Cyanides			0.50-0.90	No change
	o Highly toxic wastes	0.50-3.10	0.85-6.00	2.80-6.00	*10%
	o Heavy metals			0.20-1.00	*10-20%
Resource Recovery	o Organics	0.14-1.30	(0.06)c/-3.00	(0.25)-3.00b/	
	o Oil			0.00-0.42	*10-25%
Deep Well Injection	o Oily wastewaters	0.05-0.15	0.07-0.28	0.08-0.50	*30%
	o Toxic rinse waters	0.50-1.10	0.50-1.20	0.50-1.20	*30%
Transportation		0.08-0.17/ton-mi.	0.14-0.20/ton-mi.	0.18-0.22/ton-mi.	*10-25%
				2.70-4.50/loaded mile (20 tons per load)	*10-25%

a/ Interviews conducted in April 1983, May-July 1984, August 1985, and August-September 1986.
b/ Range for mixed halogenated solvents is $2.20 - $4.20 per gallon.
c/ Some cement kilns, light aggregate manufacturers, and steel mills pay for wastes used as fuel.
d/ High end of range can be as much as $6.00 per gallon if reactives are included.
Sources: Booz, Allen and Hamilton Inc. for 1983 figures.
ICF Incorporated for 1984 and 1985 figures.

5. RAW WASTE CHARACTERIZATION

This section characterizes and analyzes the raw wastes found in each of the hazardous waste treatment (HWT) industry subcategories: leachate, scrubber wastewater, and aqueous hazardous waste. The data presented in this section have been compiled from three sources: (1) sampling activities at 12 sites during 1986 and 1987, (2) data compiled from other U.S. Environmental Protection Agency (EPA) studies and sampling programs, and (3) the scientific literature. This section also presents a discussion of analytical methodology and factors affecting the recovery of pollutants and their quantification.

5.1 POLLUTANT ANALYSIS, RECOVERY, AND QUANTIFICATION

In order to interpret fully analytical data, quality assurance/quality control (QA/QC) information must first be evaluated. This is especially true for the analysis of organic pollutants. Of particular concern in organics analysis is percent recovery. For example, if 100 µg/l of a compound is reported, but the percent recovery is 50 percent, the real concentration could range from 100 to 200 µg/l. Conversely, if the recovery is 1,000 percent, the real concentration could be 10 µg/l. Expected recoveries for organic compounds using Contract Laboratory Program (CLP) protocols are 60 to 150 percent and for pesticides the recovery is 60 to 200 percent. The percent recovery for a compound becomes increasingly important when concentrations are low (i.e., near their detection limits).

The detection limits for the various organics in the HWT industry sampling effort ranged from 10 to 5,000 µg/l, depending on the compound and the sample. Several potential reasons include:

- A sample extract containing a large amount of organics can overload the gas chromatograph/mass spectrophotometer (GC/MS). Consequently, the full-strength extract cannot be run, making dilutions necessary and resulting in high detection limits.

- Some detection limits are high, even in "clean water." For example, the detection limit for some organics in reagent water is 10 µg/l, while in others it is 250 µg/l.

- High concentrations of a few compounds can swamp everything else. In this case, it may be necessary to use large dilutions to quantify the compounds present in high concentrations, thereby diluting those found in low concentrations. When the full strength extract is rerun to detect and quantify the low concentration compounds, the high concentration compounds mask their presence.

- A study conducted for the Office of Research and Development/Hazardous Waste Environmental Research Laboratory (ORD/HWERL) on landfill leachate has shown that less than 5 percent of the TOC in leachate can be identified using EPA's GC/MS methods. Part of the problem is that leachate contains complex organic acids (humic and fulvic materials), which are not identifiable using GC/MS methods.

- Some polar compounds (such as organic acids) are readily soluble in water, and are hard to separate and analyze with a GC. Furthermore, some polar compounds do not extract well during the extraction procedure. Some analytical chemists believe that less than 5 percent of the phenols, benzoic acid, and other organic acids found in leachates are actually extracted.

Analytical problems such as these were experienced by the laboratories used during the 1986-87 sampling programs, which resulted in pollutants not being found in samples, when high concentrations of these pollutants had been found in similar wastewaters in other samples. Therefore, the data collected from other sources are critical to the analysis presented in this section. Future Industrial Technology Division (ITD) sampling and analysis efforts will be designed to correct these problems.

Currently, EPA programs use two sets of analytical methods for toxic organics analysis. The Office of Water, including ITD, uses the 1600 and 600 Series methods (40 CFR Part 136), while the Office of Solid Waste (OSW) uses the 8000 Series analytical methods and the 3000 and 5000 Series sample preparation methods (40 CFR Part 261). For the most part, the methods are identical; however, two critical differences exist between the methods:

- The 600 and 1600 Series methods (e.g., the "water methods") include specific QC acceptance criteria that must be met in order for the analyses to be valid. Limited acceptance criteria were specified for the 8000, 3000, and 5000 Series methods (e.g., the "RCRA methods") in the second edition of SW-846, the test methods manual. The analyst ran QA/QC checks and reported the QA/QC results along with the analyses, but the QA/QC results did not have to fall within critical ranges. In the third edition of the Resource Conservation and Recovery Act (RCRA) methods, published in November 1986 (Ref. 12), acceptance criteria and critical ranges are specified; however, data obtained prior to November 1986 using the RCRA methods do not have as stringent QA/QC as data obtained with the water methods.

- The water methods require that the analyst follow a set procedure, step by step, regardless of the wastewater sample. The RCRA methods allow the analyst more flexibility to adjust for sample matrix. That is, the analyst can cleanup a sample to reduce matrix interferences if necessary and to the extent necessary prior to analysis. In the second edition of the RCRA methods, as long as the QA/QC checks were run through the same cleanup and analytical procedures, the results were acceptable. The third edition of the RCRA methods formalizes the cleanup procedures as the 3000 Series methods, but allows the analyst the choice of cleanup procedure on a sample-by-sample basis.

As a result of the flexibility in the RCRA methods and the cleanup procedures available to reduce sample matrix interferences, data obtained using these methods show higher concentrations of pollutants and the presence of more pollutants. These observations will be apparent in the following sections, which present data from sources other than this EPA-ITD study, including two studies using RCRA methods.

Variability inherent in the methods used to analyze conventional and nonconventional pollutants also must be evaluated in order to interpret analytical data. For example, EPA-ITD analytical results for $BOD\underline{5}$ are only accurate to ± 30 percent within a 95 percent degree of confidence. Consequently, dissolved $BOD\underline{5}$, a fraction of total $BOD\underline{5}$, can be reported within method accuracy limits, to be 60 percent greater than total $BOD\underline{5}$. A similar circumstance exists for ammonia, a fraction of total Kjeldahl nitrogen. The levels of precision and accuracy reported by EPA-ITD are for analyses conducted on natural water samples, not the complex matrices found in samples collected during this study. Furthermore, precision and accuracy data are not available for parameters such as COD and solids.

5.2 LEACHATE

The following sections summarize the pollutants found in raw leachate. Data were obtained from numerous sources as indicated on the data tables. Individual listings of the data are presented in Appendix A.

5.2.1 Sources of Raw Waste Data

The most recent source for analytical data characterizing the raw leachate is the 1986-1987 EPA-ITD study sampling effort. Six landfills with leachate collection were sampled during this program. The landfills sampled contained municipal refuse, industrial wastes, and hazardous wastes. The ITD sampling data are supplemented by analytical data obtained from:

- ORD/HWERL sampling efforts at 13 hazardous waste landfills in 1985
- Wisconsin Department of Natural Resources sampling efforts at 20 municipal landfills containing municipal, industrial, and hazardous wastes during 1983
- EPA Office of Emergency and Remedial Response Contract Laboratory Program (CLP) Statistical data base, "Most Commonly Occurring Analytes in 56 Leachate Samples," 1980-1983 data
- National Enforcement Investigations Center (NEIC) sampling program conducted for the Hazardous Waste Groundwater Task Force during 1985
- Subtitle D leachate data for miscellaneous Subtitle D landfills, compiled by OSW.

The data vary in the pollutants reported (i.e., conventionals, nonconventionals, metals, toxics, organics); the number of samples collected at each facility; and the data quality. QA/QC data are available only for the ITD and ORD/ HWERL sampling efforts.

5.2.2 Pollutants in the Raw Leachate

5.2.2.1 Conventional and Nonconventional Pollutants

Tables 5-1 through 5-7 summarize the conventional, nonconventional, and inorganic toxic pollutant data collected from the previously discussed sources. The data show that leachates contain high concentrations of BOD_5, COD, and TOC. These pollutants are indicators that there are high concentrations of both inorganic and organic compounds in leachates.

The fact that leachates are high-strength wastes also is reflected in the presence of other pollutants, specifically TSS, TDS, chloride, TKN, and ammonia. These pollutants were found in a wide range of concentrations. Studies have shown that leachate strength is affected by a number of factors, including landfill design, precipitation and runoff, types of wastes landfilled, landfill age, groundwater infiltration, geographic location, and geologic conditions. Under these circumstances, it may be expected that hazardous waste landfills that are the most secure (i.e., synthetically lined to exclude precipitation and groundwater) would

TABLE 5-1. CONTAMINANT CONCENTRATION RANGES IN LEACHATE REPORTED IN THE LITERATURE

Parameter	George (1972) (Ref. 27)	Chian DeWalle (1977) (Ref. 28)	Metry Cross (1977) (Ref. 29)	Cameron (1978) (Ref. 30)
pH	3.7-8.5	3.7-8.5	3.7-8.5	3.7-8.5
Alkalinity	0-20850	0-20850	310-9500	0-20900
Acidity				0-9590
Total Solids		0-59200		
TDS	0-42276	584-44900	100-51000	0-42300
Total Suspended Solids	6-2685	10-700	13-26500	
Specific Conductance		2810-16800	100-1200	
BOD	9-54610	81-33360	2200-720000	9-55000
COD	0-89520	40-89520	800-750000	0-9000
TOC		256-28000		
Bicarbonate			3260-5730	
Hardness	0-22800	0-22800	35-8700	0-22800
Chlorides	34-2800	4.7-2467	47-2350	34-2800
Fluorides				0-2.13
Sulfates	1-1826	1-1558	20-1370	0-1826
Sulfide				0-0.13
Total-K-Nitrogen	0-1416			
NH_3-Nitrogen	0-1106	0-1106	0.2-845	0-1106
Organic Nitrogen			2.4-550	
NO_3-Nitrogen	0-1300	0.2-10.29	4.5-18	
Total Phosphorus	1-154	0-130		
Ortho-Phosphorus		6.5-85	0.3-136	0-154
Aluminum				0-122
Arsenic				0-11.6
Barium				0-5.4
Beryllium				0-0.3
Boron				0.3-73
Cadmium		0.03-17		0-0.19
Calcium	5-4080	60-7200	240-2570	5-4000
Total Chromium				0-33.4
Copper	0-9.9	0-9.9		0-10
Cyanide				0-0.11
Iron	0.2-5500	0-2820	0.12-1700	0.2-5500
Lead	0-5.0	<0.10-2.0		0-5.0
Magnesium	16.5-15600	17-15600	64-547	16.5-15600
Manganese	0.06-1400	0.09-125	13	0.06-1400
Mercury				0-0.064
Molybdenum				0-0.52
Nickel				0.01-0.8
Potassium	2.8-3770	28-3770	28-3800	2.8-3770
Sodium	0-7700	0-7700	85-3800	0-7700
Titanium				0-5.0
Vanadium				0-1.4
Zinc	0-1000	0-370	0.03-135	0-1000

Note: All concentrations in mg/l except pH (standard units) and specific conductance (umhos/cm)

TABLE 5-2. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS AND METALS SUMMARY IN RAW LEACHATE EPA-ITD STUDY SAMPLING RESULTS

	Range of Concentrations(1)			Percent of Samples Where Pollutant Was Detected(3)
Pollutant	Minimum	Maximum	Mean(2)	
BOD5, mg/l	24	5040	1001	100
COD, mg/l	36	17,300	3225	100
TOC, mg/l	63	5,500	912	100
TSS, mg/l	5	4187	1467	100
TDS, mg/l	1,554	13,800	5,245	100
Chloride, mg/l	72	1839	855	100
O&G, mg/l	<1.0	552	69	67
Ammonia-N, mg/l	14	350	154	100
TKN, mg/l	14	479	165	100
NO_2 and NO_3-N, mg/l	--	--	--	--
Fluoride, mg/l	<0.1	8.7	1.2	33
Sulfide, mg/l	<0.1	0.75	0.21	17
pH, SU	6.7	8.66	--	--
Phenols, mg/l	<0.05	1.95	0.76	75
Cyanide, mg/l	<0.01	0.07	0.04	67
TVO, mg/l	--	--	--	--
Calcium, mg/l	43	1,600	346	100
Magnesium, mg/l	39	335	137	100
Sodium, mg/l	87	1,520	623	100
Aluminum	20	3,300	1,300	92
Iron	6,800	718,000	134,700	100
Manganese	450	59,300	11,800	100
Boron	170	13,000	4,980	100
Barium	57	975	366	100
Molybdenum	--	--	18	8
Antimony	<10	<10	<10	0
Arsenic	<5	63	32	75
Beryllium	<1	2	2	17
Cadmium	<5	<5	<5	0
Chromium	<10	214	74	92
Cobalt	6.6	217	70	67
Copper	<2	46	36	50
Lead	<50	<50	<50	0
Mercury	<0.2	<0.2	<0.2	0
Nickel	33	200	174	83
Selenium	<5	<5	<5	0
Silver	--	--	7.0	8
Thallium	<10	<10	<10	0
Tin	<13	<13	<13	0
Titanium	15	100	59	75
Vanadium	4.4	92	41	67
Yttrium	<10	64	42	33
Zinc	4.1	26,600	4,380	100

TABLE 5-2. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS AND METALS SUMMARY IN RAW LEACHATE EPA-ITD STUDY SAMPLING RESULTS (Continued)

NOTES:

(1) All concentrations expressed in μg/l, unless otherwise noted.

(2) Mean concentrations were calculated based on all the analyses in the EPA-ITD Sampling program where the pollutant concentration was higher than the detection limit.

(3) Data presented are based on a total of 12 samples. Percent of samples where pollutant was detected reflects the number of samples where the pollutant was detected above the detection limit. For example, molybdenum was detected in one sample, or 8% (1/12 x 100%) of the samples.

TABLE 5-3. OVERALL SUMMARY FROM THE ANALYSIS OF MUNICIPAL SOLID WASTE LEACHATES IN WISCONSIN

Parameter	Overall Range*	Typical Range (range of site medians)*	Number of Analyses
TDS	584-50430	2180-25873	172
Specific Conductance	480-72500	2840-15485	1167
Total Suspended Solids	2-140900	28-2835	2700
BOD	ND-195000	101-29200	2905
COD	6.6-97900	1120-50450	467
TOC	ND-30500	427-5890	52
pH	5-8.9	5.4-7.2	1900
Total Alkalinity ($CaCO_3$)	ND-15050	960-6845	328
Hardness ($CaCO_3$)	52-225000	1050-9380	404
Chloride	2-11375	180-2651	303
Calcium	200-2500	200-2100	9
Sodium	12-6010	12-1630	192
Total Kjeldahl Nitrogen	2-3320	47-1470	156
Iron	ND-1500	2.1-1400	416
Potassium	ND-2800	ND-1375	19
Magnesium	120-780	120-780	9
Ammonia-Nitrogen	ND-1200	26-557	263
Sulfate	ND-1850	8.4-500	154
Aluminum	ND-85	ND-85	9
Zinc	ND-731	ND-54	158
Manganese	ND-31.1	0.03-25.9	67
Total Phosphorus	ND-234	0.3-117	454
Boron	0.87-13	1.19-12.3	15
Barium	ND-12.5	ND-5	73
Nickel	ND-7.5	ND-1.65	133
Nitrate-Nitrogen	ND-250	ND-1.4	88
Lead	ND-14.2	ND-1.11	142
Chromium	ND-5.6	ND-1.0	138
Antimony	ND-3.19	ND-0.56	76
Copper	ND-4.06	ND-0.32	138
Thallium	ND-0.78	ND-0.31	70
Cyanide	ND-6	ND-0.25	86
Arsenic	ND-70.2	ND-0.225	112
Molybdenum	0.01-1.43	0.034-0.193	7
Tin	ND-0.16	0.16	3
Nitrite-Nitrogen	ND-1.46	ND-0.11	20
Selenium	ND-1.85	ND-0.09	121
Cadmium	ND-0.4	ND-0.07	158
Silver	ND-1.96	ND-0.024	106
Beryllium	ND-0.36	ND-0.008	76
Mercury	ND-0.01	ND-0.001	111

Note: ND = not detected

*All concentrations in mg/l except pH (standard units) and specific conductance (umhos/cm)

TABLE 5-4. MOST COMMONLY OCCURRING CONVENTIONALS, NONCONVENTIONALS, AND METALS IN LEACHATE SAMPLES -- CLP DATABASE, 1980-1983 DATA

Pollutant	Range of Concentrations* Minimum	Maximum	Mean	Number of Analyses
Ammonia, mg/l	17.0	51.0	34.0	2
Fluoride, mg/l	--	--	0.4	1
Cyanide, mg/l	0.033	2.50	1.266	2
Calcium, mg/l	92.2	109	62.6	3
Magnesium, mg/l	29.7	68.7	43.1	3
Sodium, mg/l	40.8	84.9	69.6	3
Aluminum	300	2,700,000	364,501	12
Iron	160	4,300,000	458,514	18
Manganese	270	650,000	100,149	13
Boron	0	4,500	1,486	10
Barium	227	160,000	19,798	9
Antimony	--	--	--	1
Arsenic	0	1,900	392	6
Beryllium	0	59	25	4
Cadmium	3.3	2,100	426	5
Chromium	21	22,400	3,649	9
Cobalt	24	5,400	1,052	6
Copper	36	100,000	16,761	6
Lead	10	75,000	8,536	9
Mercury	0	70	26	4
Nickel	60	12,000	2,362	6
Selenium	0	40	20	2
Tin	0	72	36	2
Vanadium	0	5,900	1,215	5
Zinc	40	320,000	19,177	18

* All concentration expressed in μg/l, unless otherwise noted.

TABLE 5-5. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS AND METALS IN MISCELLANEOUS SUBTITLE D LANDFILL LEACHATES

Pollutant	Range of Concentrations(1)			Number of Samples Where Pollutant Was Detected
	Minimum	Maximum	Mean	
COD, mg/l	440	15,820	3,689	16
TOC, mg/l	<5	6,880	2,115	8
BOD5, mg/l	7	9,044	2,275	8
TSS, mg/l	29	310	218	3
TDS, mg/l	1,400	10,100	5,696	9
Ammonia as N, mg/l	11.3	1,200	290	17
TKN, mg/l	66	938	477	3
Chloride, mg/l	120	5,475	785	18
Fluoride, mg/l	0.12	0.79	0.42	4
Total Cyanide, mg/l	0.004	0.02	0.012	2
Sulfate, mg/l	8	346	98	12
Sodium, mg/l	183	929	480	6
Calcium, mg/l	96	516	248	5
Magnesium, mg/l	76	927	225	7
Arsenic	<1	80	30	7
Barium	200	500	327	6
Cadmium	<0.1	40	16	9
Chromium, Total	1	180	57	10
Beryllium	5	10	7.5	2
Copper	3	150	69	10
Iron	1,700	1,300,000	214,000	17
Lead	<1	1,050	188	12
Manganese	260	43,000	11,190	9
Mercury	<0.1	6.0	2.0	7
Nickel	40	1,070	346	9
Selenium	<1	20	10	7
Zinc	<10	67,000	8,440	15
Antimony	470	1,100	785	2
Silver	<10	50	30	5
Thallium	80	80	80	2
Cobalt	--	--	40	1

NOTE:

(1) All concentrations expressed in µg/l, unless noted otherwise.

TABLE 5-6. POLLUTANTS IN HAZARDOUS WASTE LANDFILL LEACHATES - ORD/HWERL STUDY

Parameter	Range of Detected Constituent(1)(2) Minimum	Maximum	Mean	Percent of Sites Where Pollutant Was Detected
COD (mg/l)	1,950	23,300	10,217	100
TOC (mg/l)	195	11,750	3,097	100
Total Cyanide (mg/l)	0.01	55	9.9	69
pH (SU)	7.1	9.3	--	--
Eh (volts)	-0.343	-0.093	-0.226	100
Conductivity (micromhos/cm)	4,250	20,000	14,694	100
Temperature (°C)	19.9	32	26.7	100
Silver	0.3	32.8	6.6	100
Arsenic	458	129,600	13,097	77
Beryllium	0.2	7.4	0.81	46
Cadmium	0.7	102	18.7	100
Chromium	0.2	1,734	281	100
Copper	2.3	17,030	1,885	100
Mercury	0.045	39.3	5.0	92
Nickel	17.3	67,110	6,417	100
Lead	0.3	1006	116	100
Antimony	13	5240	522	85
Selenium	221	3488	1,168	100
Thallium	9.4	156	36.9	85
Zinc	5.12	24,510	2,513	100

NOTES:

(1) All concentrations expressed in ug/l, unless otherwise noted.

(2) Data presented are the results of sampling efforts at 13 sites. Data collected from each site are summarized in Appendix A-1, Table 7.

TABLE 5-7. POLLUTANTS IN HAZARDOUS WASTE (SUBTITLE C) LANDFILL LEACHATES - NEIC STUDY

Pollutant	Range of Concentrations(1)(2) Minimum	 Maximum	 Mean	Percent of Sites Where Pollutant Was Detected
TOC, mg/l	11,410	30,400	20,905	100
TVO, mg/l	470	810	640	100
Ammonia as N, mg/l	8.7	5,000	1,328	100
Cyanides, mg/l	0.013	77.1	8.9	90
Phenols, mg/l	0.14	370	93.4	100
Fluoride, mg/l	1.5	24	8.8	100
Chloride, mg/l	460	37,000	13,460	100
Bromide, mg/l	25	970	417	100
Sulfate, mg/l	32	11,000	2,833	100
Nitrate, mg/l	20	460	124	71
Sodium, mg/l	53	25,000	6,420	100
Calcium, mg/l	68	4,950	832	100
Magnesium, mg/l	24	906	248	100
Aluminum	149	929,000	166,580	73
Antimony	220	1,700	712	58
Arsenic	63	1,600,000	125,620	86
Barium	270	6,230	1,441	59
Beryllium	29	56	42	10
Cadmium	23	841,000	117,800	50
Chromium	59	102,000	7,859	64
Cobalt	23	12,300	1,305	59
Copper	40	2,800	603	86
Iron	1,100	4,080,000	495,030	100
Lead	64	11,600	1,374	50
Manganese	345	131,000	16,514	100
Mercury	1.1	14	4.0	36
Nickel	243	38,900	7,767	95
Selenium	90	3,820	762	41
Silver	33	35	34	13
Tin	488	2,080	1,284	14
Titanium	220	25,400	6,598	50
Vanadium	61	2,160	484	77
Zinc	305	38,800	7,367	95

NOTES:

(1) All concentrations expressed in µg/l, unless noted otherwise.

(2) Data presented represents the results of the NEIC Study sampling at 6 sites. Appendix A-5 contains the sampling data used to prepare this table.

have the highest concentrations of conventional, nonconventional, and toxic pollutants. However, when the municipal landfill leachate data (Tables 5-2 through 5-5) and the hazardous waste landfill leachate data (Tables 5-6 and 5-7) were compared, this hypothesis was found to be invalid. A likely explanation is that the high COD, BOD$_5$, TOC, TSS, TDS, chloride, ammonia, and TKN concentrations found in municipal landfill leachate are the result of anaerobic decomposition of paper and paperboard products. High organic concentrations (COD, BOD, TOC) also might be attributed to leachate contact with sugars and starches found in municipal landfills.

5.2.2.2 Toxic Pollutants

Metals

Metals data for leachate samples are summarized in Tables 5-1 through 5-7. These data show that:

- Leachates contain almost all of the metals, ranging in concentration from below detection limits to hundreds of milligrams per liter
- Subtitle D landfills contain metals at concentrations equivalent to hazardous waste landfills.

Generally, leachates have been found to contain high concentrations of boron, aluminum, iron, manganese, and zinc.

Toxic metals, such as arsenic, barium, copper, chromium, lead, mercury, nickel, and zinc, are found at a wide range of concentrations and in many cases at very high concentrations. For example, arsenic ranged from not detected (ND) to 70.2 mg/l in Wisconsin leachate samples (Table 5-3), and from 63 µg/l to 1,260 mg/l in NEIC leachate samples (Table 5-7). Antimony, beryllium, cadmium, molybdenum, selenium, silver, and tin generally were found at low concentrations.

Organic Compounds

Data for organic pollutants from six studies are summarized in Table 5-8. In some studies a given compound may not be reported because the leachate was not tested for that compound, not because the compound was not present in the leachate. The information from the EPA-ITD Study, CLP data base, Wisconsin Study, and from other miscellaneous Subtitle D landfills in Table 5-8 present the organic compounds found in primarily Subtitle D landfill leachates, using

TABLE 5-8 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE

POLL. #	POLLUTANT NAME	EPA ITD STUDY				CLP Database				Wisconsin Study				Misc. Subtitle D				ORD/HWERL Study				NEIC Study			
		No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean
44	Methylene Chloride	12	0	1224	230	20	1	12000	1838	24	7	20000	1910	8	0	3300	615	13	19	56800	14100	13	25	620000	111344
25	Dichlorobenzene	0	0	0	0					17	0	13	10					2	173	46000	23087	3	1000	20000	13667
11	1,1,1-Trichloroethane	0	0	0	0	0	0	0	0	22	0	2400	210	8	0	200	38	5	37	22000	4761	11	13	100000	12719
87	Trichloroethylene	0	0	0	0	7	1	97	46	23	0	1120	188	6	1	43	16	11	13	11300	2406	14	5	300000	28089
23	Chloroform	0	0	0	0	3	310	310	310	22	8	1300	102	5	0	100	51	10	3	7250	2521	8	5	55000	12244
7	Chlorobenzene	0	0	0	0	7	2	140	57	16	1	10	8	5	0	237	63	6	107	2480	1040	12	5	70000	9177
10	1,2-Dichloroethane	0	0	0	0	0	0	0	0	23	0	11000	540	0	0	0	0	1	9040	9040	9040	5	3100	57000	23020
13	1,1-Ddichloroethane	12	0	25	11	0	0	0	0	23	5	6300	513	5	0	140	47	4	47	1620	593	8	10	3000	968
27	1,4-Dichlorobenzene	0	0	0	0					19	0	37	11	0	0	0	0	2	186	6300	3243	4	10	9000	4253
85	Tetrachloroethylene	0	0	0	0	4	27	97	62	22	2	620	92	6	0	100	56	7	5	1800	799	11	5	210000	22673
30	Trans,-1,2-Dichloroethylene	12	0	191	33	7	2	336	76	22	0	2760	518	5	4	230	52	5	11	1610	431	8	5	6900	1231
26	1,3-Trichlorobenzene																	2	150	990	570	0	0	0	0
6	Carbon Tetrachloride	0	0	0	0					0	0	0	0	6	0	398	73	1	879	879	879	3	310	70000	25437
14	1,1,2-Trichloroethane	0	0	0	0					22	0	500	81	0	0	0	0	2	42	231	137	4	1800	70000	35700
32	1,2-Dichloropropane	0	0	0	0					7	2	86	17	0	0	0	0	3	82	186	144	1	260	260	260
20	2-Chloronapthalene	0	0	0	0					1	46	46	46												
16	Chloroethane	0	0	0	0	4	12	20	16	22	0	860	108	0	0	0	0								
552	Trichlorofluoroethane	0	0	0	0					22	6	110	56	0	0	0	0								
R138	1,3-Dichloropropylene									18	0	30	11												
88	Vinyl Chloride	12	0	649	63	3	19	106	63	18	0	61	14	0	0	0	0	0	0	0	0	3	50	2700	933
15	1,1,2,2-Tetrachloroethane	0	0	0	0					1	210	210	210	0	0	0	0	0	0	0	0	5	230	500000	136874
46	Methyl Bromide	0	0	0	0					1	170	170	170	0	0	0	0								
45	Methyl Chloride	0	0	0	0					1	170	170	170	0	0	0	0								
R366	Fluorotrichloroethane					3	11	33	19																
29	1,1-Dichloroethene	0	0	0	0	3	5	5	5									0	0	0	0	1	380	380	380
50	Dichlorodifluoroethane	0	0	0	0	1	205	205	205	1	180	180	180	1	369	369	369								
	Chloromethyl-Oxirane	0	0	0	0	1	100	100	100																
86	Toluene	12	0	132	39	15	5	3700	894	23	0	3200	787	8	0	510	115	13	31	33600	8340	17	15	510000	40184
HC250	Total Xylenes					3	9	2500	850					0	0	0	0	11	60	5160	1822	13	7	370000	64991
55	Naphthalene	8	0	13	10	3	18	26	22	21	0	68	20	1	4	4	4	4	27	5200	1521	6	10	35000	6363
4	Benzene	12	0	24	12	12	3	25	15	23	0	1080	255	4	0	26	10	12	9	720	328	13	7	6900	2429
38	Ethylbenzene	12	0	95	27	9	20	460	208	23	0	4900	423	7	0	580	100	10	16	1100	434	13	5	100000	17608
V074	Trimethyl Benzene(Isomer)																	2	143	300	222				
904	2-Methylnaphthalene																	2	120	3400	1760	4	15	460	143
	1,2,3-Trimethyl Benzene																	1	2240	2240	2240				
81	Phenanthrene	0	0	0	0	4	24	25	25									1	300	300	300	2	32	53	43

TABLE 5-8 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE (CONTINUED)

POLL. #	POLLUTANT NAME	EPA ITD STUDY				CLP Database				Wisconsin Study				Misc. Subtitle D				ORD/HWERL Study				NEIC Study			
		No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean
	1-Ethyl-2-Methyl Benzene																	1	346	346	346				
77	Acenaphthylene	0	0	0	0	1	15	15	15									1	150	150	150	2	10	50	30
	Tetramethyl Benzene ,Isomer																	1	255	255	255				
	Propyl Benzene																	1	176	176	176				
56	Nitrobenzene	0	0	0	0	1	10	10	10	23	0	120	27												
	1,3-Dimethyl benzene					1	4600	4600	4600																
78	Anthracene	0	0	0	0	4	16	25	20																
1	Acenaphthene	0	0	0	0	3	45	45	45																
39	Fluoranthene	0	0	0	0	3	10	60	28									0	0	0	0	1	12	12	12
84	Pyrene	0	0	0	0	3	8	53	25																
72	Benzo(a)Anthracene	0	0	0	0	2	13	16	14																
74	Benzo(b)Fluoranthene	0	0	0	0	2	11	11	11																
75	Benzo(k)Fluoranthene	0	0	0	0	2	11	11	11																
76	Chrysene	0	0	0	0	2	16	16	16																
557	Aniline	0	0	0	0	1	74	74	74									3	14200	56000	33733	5	1200	820000	330840
	N,N-Dimethyl Acetamide																	1	13800	13800	13800	0	0	0	0
569	4-Chloroaniline																	2	12000	15500	13750	0	0	0	0
	1-Methyl-2-Pyrrolidinone																	3	360	14400	6150	0	0	0	0
	Isoquinoline																	1	3020	3020	3020				
	Azepin-2-One,Hydro-,2H-																	1	7410	7410	7410				
930	Pyridine																	1	11500	11500	11500	0	0	0	0
	2-Chloro-Pyridine																	2	3880	6200	5040				
	4-Methyl Benzenesulfonamide																	5	202	6020	1720				
65	Phenol	0	0	0	0	9	59	2200	467	22	0	11300	1713	7	0	28800	5357	13	2400	110000	21590	18	140	140000	41434
944	4-(P-Cresol)Methylphenol	0	0	0	0	4	6	6700	1792									12	110	47000	12300	10	12	46000	10087
943	Benzoic Acid																	8	3090	20600	11560	11	1000	520000	145182
	Butanoic Acid					2	36	1600	818									4	2400	49400	19900				
	2-Methyl-Propanoic Acid																	4	3660	17000	8380				
	Pentanoic Acid																	3	4180	21500	13990				
	Alkanoic Acid																	2	1120	50100	25610				
947	Hexanoic Acid	0	0	0	0	1	2300	2300	2300									2	3600	39700	21650				
34	2,4-Dimethylphenol	0	0	0	0	2	22	22	22	20	10	2828	24					9	30	12000	3817	6	77	15000	3186
	Phenylacetic Acid																	5	1660	6400	3740				
	4-(Methylthio)-Phenol																	1	770	770	770				
	Octanoic Acid																	1	9440	9440	9440	0	0	0	0
	2-Methyl-Butanoic Acid					1	63	63	63									3	510	2610	1820				

TABLE 5-8 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE (CONTINUED)

POLL. #	POLLUTANT NAME	EPA ITD STUDY				CLP Database				Wisconsin Study				Misc. Subtitle D				ORD/HWERL Study				NEIC Study			
		No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean
31	2,4-Dichlorophenol																	4	87	2900	1529				
	2,4,6-Trimethyl-Phenol																	1	5720	5720	5720				
	Phenolpropanoic Acid																	4	27	2230	890				
64	Pentachlorophenol	0	0	0	0	4	3	470	381	23	0	470	46					1	1900	1900	1900				
	2,2-Dimethyl-Propanoic Acid																	1	228	228	228				
	4-Chloro-Benzoic Acid																	1	8220	8220	8220				
21	2,4,6-Trichlorophenol																	1	3860	3860	3860				
R132	(2,4-Dichlorophenoxy)-Acetic Acid																	1	898	898	898	2	80	440	260
531	2,4,5-Trichlorophenol																	1	3440	3440	3440				
	2,5-Dichlorophenol																	1	2760	2760	2760				
	1-Napthalene Carboxylic Acid																	1	618	618	618				
	4-4'-Methylenebis-Phenol																	1	5540	5540	5540				
24	2-Chlorophenol																	1	1790	1790	1790	3	10	130	62
	4-(1,1-Diethyl-ethyl)-Benzoic Acid																	1	675	675	675				
	4-Methoxy-Phenylacetic Acid																	1	710	710	710				
	3,4-Dichloro-Benzoic Acid																	1	1210	1210	1210				
	3-(1,1-Dimethylethyl)-Phenol																	1	525	525	525				
	1,2-Dicarboxylic Acid Benzene																	1	33	33	33				
	2,5-Dimethyl Phenol																	1	318	318	318				
22	4-Chloro-3-Methylphenol	6	0	14	11													1	36	36	36				
58	4-Nitrophenol	0	0	0	0					1	17	17	17												
	Benzeneacetic Acid					2	4	350	177																
	Butanoic Acid,Ethyl Ester					1	23	23	23																
	Butanoic Acid,Methyl Ester					1	12	12	12																
	2-Methyl Hexanoic Acid					1	480	480	480																
516	Acetone	12	0	1671	253	4	630	850	727					0	0	0	0	13	344	77500	23200	15	100	1E+06	292273
514	2-Butanone	12	0	7855	1825	2	960	2400	1680									12	62	42900	14710	12	6000	390000	190042
564	Benzyl Alcohol	9	0	55	16	1	3800	3800	3800									6	1740	68000	24120				
	4-Methyl-2-Pentanol					2	130	580	355																
545	2-Hexanone																	13	17	17200	4610	1	15000	15000	15000
	4-Methyl-2-Pentanol																	2	2450	33000	17720	4	3000	24000	12750
	2-Methyl Cyclopentanol																	2	1130	17800	9460				
	1,1'-Oxybis(2-Methoxy-) Ethane																	2	540	16600	8570				
	2-Butoxy-Ethanol																	2	1560	3740	2650	0	0	0	0
550	4-Methyl-2-Pentanone	0	0	0	0	3	150	380	265									11	9	3790	915	12	240	71000	16636
	2-(2-Butoxyethoxy)-Ethanol																	3	940	10800	5580				

TABLE 5-8 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE (CONTINUED)

POLL. #	POLLUTANT NAME	EPA ITD STUDY				CLP Database				Wisconsin Study				Misc. Subtitle D				ORD/HWERL Study				NEIC Study			
		No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean
	Cyclohexanone																	3	1650	3930	3067	0	0	0	0
	Benzene-1,2-Dicarboxylic Acid Anhyd.																	3	1020	6720	3970				
	2,2,4-Trimethyl-1,3-Pentanediol																	2	810	5490	3150				
54	Isophorone	10	0	2396	255	2	5	110	58	23	0	16000	970	0	0	0	0	1	15000	15000	15000	6	10	1500	710
	2,2-Dimethyl-1,3-Propanediol																	2	588	2440	1510				
	Tributylester Phosphoric Acid																	1	18200	18200	18200				
	2-Ethyl-1-Hexanol																	3	434	1860	960				
	1-(2-Methoxy-1-Methylethoxy)-2-Propanol																	2	112	1550	830				
	1,2,4,6-Tetrathiepane																	1	3020	3020	3020				
	1-(2-Butoxyethoxy)-Ethanol																	2	1230	8860	5040				
	2,2'-Thiobis-Ethanol																	1	3930	3930	3930				
	4-Hydroxy-3Methoxy Benzaldehyde																	1	770	770	770				
	1,3(2H)-Dione,1H-Isoindole																	1	1490	1490	1490				
	Napthol(1,8-CD)Pyran-1,3-Dione,1H,3H																	2	31	692	360				
	Sulfonybis-Methane																	1	1560	1560	1560				
	2-Methyl-2,4-Pentanediol																	1	2660	2660	2660				
68	Di-n-Butylphthalate	0	0	0	0	0	0	0	0	23	0	150	25	0	0	0	0	9	23	996	312	2	10	31	21
	2-[2-(2-Ethoxy-ethoxy)Ethoxy]-Ethanol																	1	1560	1560	1560				
	9,10-Anthracenedione																	1	750	750	750				
	Isoindole-1,3(2h)-Dione,3A,4,7,7A-Tetrah																	1	1630	1630	1630				
	Triphenyl-Phosphineoxide																	1	2390	2390	2390				
	2-Phenyl-2-01-Propan																	2	226	402	314				
	1,2-Dicarboxylic Acid Anhydride Cyclohex																	1	1030	1030	1030				
	Alcanol																	1	1020	1020	1020				
66	Bis(2-Ethylhexyl) Phthalate	0	0	0	0	14	12	3700	768	23	0	150	33	0	0	0	0	1	1480	1480	1480	5	65	10000	2372
71	Dimethyl Phthalate	0	0	0	0	2	26	26	26	21	0	55	17	0	0	0	0	1	820	820	820	1	2200	2200	2200
	Methyl Acetophenone																	1	131	131	131	0	0	0	0
69	D-n-Octyl Phthalate																	1	31	31	31	1	13	13	13
19	2-Chloroethyl Vinyl Ether	0	0	0	0					19	0	1100	70												
43	Bis(2-Chloroethoxy)Methane	0	0	0	0	1	13	13	13	20	0	25	11												
17	Bis(Chloromethyl) Ether	0	0	0	0					1	250	250	250												
70	Diethyl Phthalate	8	0	38	14	7	25	84	45	23	0	330	101	0	0	0	0	0	0	0	0	1	2100	2100	2100
67	Butyl Benzyl Phthalate	0	0	0	0	0	0	0	0	23	0	150	27					0	0	0	0	1	490	490	490
	2-Ethyl-1,4-Dimethyl-Benzene																	1	965	965	965				
510	Styrene																	1	637	637	637	3	180	43000	14627
	1,3-Diamino-4-Methyl Benzene																	1	2480	2480	2480				

TABLE 5-8 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE (CONTINUED)

POLL. #	POLLUTANT NAME	EPA ITD STUDY				CLP Database				Wisconsin Study				Misc. Subtitle D				ORD/HWERL Study				NEIC Study			
		No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean
	1,4-Diamino-Benzene																	1	1940	1940	1940				
	1,2-Diamino-Benzene																	1	835	835	835				
	Benzamide																	1	1500	1500	1500				
	4-Hydroxy-4-Methyl-2-Pentanone					2	710	76000	38355																
	Ethanol					1	42	42	42																
	Bis(2-Chloroethoxy) Ethane					1	13	13	13																
	1,1'-Oxybis-2-Ethoxy Ethane					1	460	460	460																
	Methane, Thiobis					1	47	47	47																
585	N,N-Diemethyl Foramide	0	0	0	0	1	15000	15000	15000																
	2,4-Diemethyl Heptane					1	150	150	150																
	2,3,5-Trimethyl Hexane					1	29	29	29																
	4-Ethyl-2-Methyl Hexane					1	160	160	160																
91	Chlordane					1	200	200	200																
112	PCB-1016					1	629	629	629																
	MCPP	1	6	6	6																				
	TEPP	2	665	1193	929																				
2	Acrolein	0	0	0	0					1	270	270	270									9	180	3E+06	541542
515	Ethyl Ether	12	0	1795	243																	2	3000	14000	8500
8	1,2,4-Trichlorobenzene	0	0	0	0	2	80	80	80									0	0	0	0	3	580	29000	16193
571	O-Cresol	9		25	12	3	5	360	140									10	94	24000	5300	6	14	21000	3582
509	Alpha-Terpineol	8	0	121	36	0	0	0	0																
506	N-Dodecane	8	0	62	17	1	0	0	0																
513	P-Cymene	8	0	17	11																				
936	Thioxanthone	9	0	286	50																				
554	Vinyl Acetate	12	0	17	11																				
523	N-Tetracosane	8	0	153	28																				
18	Bis(2-Chloroethylether)	8	0	12	10																				
580	1,2,3,4-Diepoxybutane	10	0	338	43																				
578	2,3-Dichloro-Aniline																	1	1150	1150	1150				
502	2-Amino Naphthalene																	1	942	942	942				
	2-Methoxy Aniline																	1	515	515	515				
	2-Methyl Benzenesulfonamide																	1	114	114	114				
	2-Pyridinamine																	1	560	560	560				
	4-Ethyl-Morpholine																	1	520	520	520				
	1,1,7-Trimethyl Bycyclo(2,2,1)Hept-2-ene																	1	17300	17300	17300				
	n-Alkanes(c)*																	1	9540	9540	9540				

TABLE 5-8 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE (CONTINUED)

POLL.	POLLUTANT NAME	EPA ITD STUDY				CLP Database				Wisconsin Study				Misc. Subtitle D				ORD/HWERL Study				NEIC Study			
#		No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean
	2,2,4,6,6-Pentamethyl-Heptane																	1	4760	4760	4760				
	Heptadecane																	2	575	5440	3010				
	n-Alkanes(A)*																	1	3380	3380	3380				
	n-Alkanes(D)*																	1	3740	3740	3740				
	n-Alkanes(B)*																	1	2700	2700	2700				
	2-Propenylidene-Cyclobutane																	1	75	75	75				
106	PCB-1242																					3	300	240000	86767
107	PCB-1254																					1	700	700	700
	Tetrahydrofuran																					8	4000	600000	137875
538	1,2-Dibromoethane																					3	2200	19000	9733
	2-Methyl-2-Butanol																					1	71000	71000	71000
	2-Butanol																					4	20000	490000	148000
9	Hexachlorobenzene																	0	0	0	0	1	10000	10000	10000
12	Hexachloroethane																	0	0	0	0	1	10000	10000	10000
52	Hexachlorobutadiene																	0	0	0	0	1	30000	30000	30000
933	1,2,4,5-Tetrachlorobenzene																					1	10000	10000	10000
R071	P-Chloroaniline																					1	1600	1600	1600
921	Pentaclorobenzene																					1	20000	20000	20000
	Bromochloromethane																					1	1E+05	130000	130000
48	Bromodichloromethane																	0	0	0	0	1	360	360	360
533	Carbon Disulfide																	0	0	0	0	3	40	2500	1147
505	Dibenzofuran																	0	0	0	0	2	11	32	22
80	Fluorene																	0	0	0	0	2	13	38	26
547	Isobutyl Alcohol																					1	1000	1000	1000
3	Acrylonitrile																					2	3	6	4
527	1,4-Dioxane																					6	400	80000	23717
104	Gamma-BHC																					1	7800	7800	7800
102	Alpha-BHC																					1	5400	5400	5400
	2-(2-Ethoxyethoxy) Ethanol																	1	1210	1210	1210	0	0	0	0

NOTES:

(1)- All units in ug/l
(2)- Zero (0) indicates pollutant was analyzed for and not detected
(3)- No value indicates pollutant was not analyzed
(*)- Percent of Sites where pollutant was detected

the Water Program's analytical methods. Because the data were collected from several sources, there may be a few samples of leachate from hazardous waste landfills, either active or inactive, included in Table 5-8. It also is possible that RCRA analytical methods may have been used for a few samples; however, the vast majority of the leachates are from Subtitle D facilities and were analyzed using the Water Program methods. The data from the ORD/HWERL and NEIC studies in Table 5-8 present the organic compounds found in solely hazardous waste (Subtitle C) landfills, using the RCRA analytical methods. Table 5-9 is a composite of the 6 studies listed in Table 5-8.

According to the data in Table 5-8, the toxic organic portion of the ORD/HWERL leachates were composed primarily of base/neutral extractable compounds and organic acids, both in terms of the number of compounds and their concentrations, although some volatile compounds were found at very high concentrations. The Wisconsin leachates contained primarily volatile compounds (both halogenated and aromatics) as did the leachates from the miscellaneous Subtitle D landfills; however, the predominance of volatile compounds in the results of these two studies may be due to analytes dominated by volatile compounds. Both the CLP data base and the EPA-ITD study leachates showed a fairly even mix of volatile, base/neutral extractable, and acid extractable compounds. Although the list of analytes for the EPA-ITD study leachates included all of the Appendix IX organics, few organic compounds were found and at relatively low concentrations. The NEIC study leachates were evenly divided between volatile and base/neutral organic compounds.

One hundred and sixty-two organic compounds were found in the ORD/HWERL and NEIC studies, which sampled hazardous waste landfill leachates using RCRA analytical methods, compared to 97 organic compounds in the Subtitle D landfill leachates using Water Program analytical methods. The concentrations of individual compounds also were significantly higher in the hazardous landfill leachates. This suggests that leachates from hazardous waste landfills contain more toxic organic compounds and at higher concentrations than Subtitle D landfill leachates. However, the use of different analytical methods also may have contributed to the difference in analytical results. Another factor is that the list of analytes differed for each study; however, the EPA-ITD study, which used the most extensive list of analytes, found both the fewest organic compounds in the leachates and some of the lowest concentrations.

Table 5-10 lists the most frequently found organic compounds in leachates (i.e., those found in at least 50 percent of the leachates sampled). These data show that approximately 25 toxic organic compounds are found frequently in landfill leachates. Three compounds (i.e., methylene chloride, toluene, and benzene) were found in 50 percent or more of the leachate samples from four or more of the studies reported in Table 5-8.

TABLE 5-9 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE
COMPOSITE OF DATA SOURCES

POLL. #	POLLUTANT NAME	OVERALL-COMPOSITE Min.	Max.	Mean
44	Methylene Chloride	0	620000	21673
25	Dichlorobenzene	0	46000	9191
11	1,1,1-Trichloroethane	0	100000	2955
87	Trichloroethylene	0	300000	5124
23	Chloroform	0	55000	2538
7	Chlorobenzene	0	70000	1724
10	1,2-Dichloroethane	0	57000	5433
13	1,1-Ddichloroethane	0	6300	355
27	1,4-Dichlorobenzene	0	9000	1501
85	Tetrachloroethylene	0	210000	3947
30	Trans,-1,2-Dichloroethylene	0	6900	390
26	1,3-Trichlorobenzene	0	990	285
6	Carbon Tetrachloride	0	70000	5278
14	1,1,2-Trichloroethane	0	70000	7184
32	1,2-Dichloropropane	0	260	84
20	2-Chloronapthalene	0	46	23
16	Chloroethane	0	860	31
552	Trichlorofluoroethane	0	110	19
R138	1,3-Dichloropropylene	0	30	11
88	Vinyl Chloride	0	2700	179
15	1,1,2,2-Tetrachloroethane	0	500000	27417
46	Methyl Bromide	0	170	57
45	Methyl Chloride	0	170	57
R366	Fluorotrichloroethane	11	33	19
29	1,1-Dichloroethene	0	380	96
50	Dichlorodifluoroethane	0	369	189
	Chloromethyl-Oxirane	0	100	50
86	Toluene	0	510000	8393
HC250	Total Xylenes	0	370000	16916
55	Naphthalene	0	35000	1323
4	Benzene	0	6900	508
38	Ethylbenzene	0	100000	3133
V074	Trimethyl Benzene(Isomer)	143	300	222
904	2-Methylnaphthalene	15	3400	952
	1,2,3-Trimethyl Benzene	2240	2240	2240
81	Phenanthrene	0	300	92
	1-Ethyl-2-Methyl Benzene	346	346	346
77	Acenaphthylene	0	150	49
	Tetramethyl Benzene ,Isomer	255	255	255
	Propyl Benzene	176	176	176
56	Nitrobenzene	0	120	12
	1,3-Dimethyl benzene	4600	4600	4600
78	Anthracene	0	25	10
1	Acenaphthene	0	45	23
39	Fluoranthene	0	60	10
84	Pyrene	0	53	13
72	Benzo(a)Anthracene	0	16	7

TABLE 5-9 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE COMPOSITE OF DATA SOURCES (CONTINUED)

POLL. #	POLLUTANT NAME	OVERALL-COMPOSITE		
		Min.	Max.	Mean
74	Benzo(b)Fluoranthene	0	11	6
75	Benzo(k)Fluoranthene	0	11	6
76	Chrysene	0	16	8
557	Aniline	0	820000	91162
	N,N-Dimethyl Acetamide	0	13800	6900
569	4-Chloroaniline	0	15500	6875
	1-Methyl-2-Pyrrolidinone	0	14400	3075
	Isoquinoline	3020	3020	3020
	Azepin-2-One,Hydro-,2H-	7410	7410	7410
930	Pyridine	0	11500	5750
	2-Chloro-Pyridine	3880	6200	5040
	4-Methyl Benzenesulfonamide	202	6020	1720
65	Phenol	0	140000	11760
944	4-(P-Cresol)Methylphenol	0	47000	6045
943	Benzoic Acid	1000	520000	78371
	Butanoic Acid	36	49400	10359
	2-Methyl-Propanoic Acid	3660	17000	8380
	Pentanoic Acid	4180	21500	13990
	Alkanoic Acid	1120	50100	25610
947	Hexanoic Acid	0	39700	7983
34	2,4-Dimethylphenol	0	15000	1410
	Phenylacetic Acid	1660	6400	3740
	4-(Methylthio)-Phenol	770	770	770
	Octanoic Acid	0	9440	4720
	2-Methyl-Butanoic Acid	63	2610	942
31	2,4-Dichlorophenol	87	2900	1529
	2,4,6-Trimethyl-Phenol	5720	5720	5720
	Phenolpropanoic Acid	27	2230	890
64	Pentachlorophenol	0	1900	582
	2,2-Dimethyl-Propanoic Acid	228	228	228
	4-Chloro-Benzoic Acid	8220	8220	8220
21	2,4,6-Trichlorophenol	3860	3860	3860
R132	(2,4-Dichlorophenoxy)-Acetic Acid	80	898	579
531	2,4,5-Trichlorophenol	3440	3440	3440
	2,5-Dichlorophenol	2760	2760	2760
	1-Napthalene Carboxylic Acid	618	618	618
	4-4'-Methylenebis-Phenol	5540	5540	5540
24	2-Chlorophenol	10	1790	926
	4-(1,1-Diethyl-ethyl)-Benzoic Acid	675	675	675
	4-Methoxy-Phenylacetic Acid	710	710	710
	3,4-Dichloro-Benzoic Acid	1210	1210	1210
	3-(1,1-Dimethylethyl)-Phenol	525	525	525
	1,2-Dicarboxylic Acid Benzene	33	33	33
	2,5-Dimethyl Phenol	318	318	318
22	4-Chloro-3-Methylphenol	0	36	24
58	4-Nitrophenol	0	17	9

TABLE 5-9 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE COMPOSITE OF DATA SOURCES (CONTINUED)

POLL. #	POLLUTANT NAME	OVERALL-COMPOSITE Min.	Max.	Mean
	Benzeneacetic Acid	4	350	177
	Butanoic Acid,Ethyl Ester	23	23	23
	Butanoic Acid,Methyl Ester	12	12	12
	2-Methyl Hexanoic Acid	480	480	480
516	Acetone	0	1000000	63291
514	2-Butanone	0	390000	52064
564	Benzyl Alcohol	0	68000	9312
	4-Methyl-2-Pentanol	130	580	355
545	2-Hexanone	17	17200	9805
	4-Methyl-2-Pentanol	2450	33000	15235
	2-Methyl Cyclopentanol	1130	17800	9460
	1,1'-Oxybis(2-Methoxy-) Ethane	540	16600	8570
	2-Butoxy-Ethanol	0	3740	1325
550	4-Methyl-2-Pentanone	0	71000	4454
	2-(2-Butoxyethoxy)-Ethanol	940	10800	5580
	Cyclohexanone	0	3930	1534
	Benzene-1,2-Dicarboxylic Acid Anhyd.	1020	6720	3970
	2,2,4-Trimethyl-1,3-Pentanediol	810	5490	3150
54	Isophorone	0	16000	2832
	2,2-Dimethyl-1,3-Propanediol	588	2440	1510
	Tributylester Phosphoric Acid	18200	18200	18200
	2-Ethyl-1-Hexanol	434	1860	960
	1-(2-Methoxy-1-Methylethoxy)-2-Propanol	112	1550	830
	1,2,4,6-Tetrathiepane	3020	3020	3020
	1-(2-Butoxyethoxy)-Ethanol	1230	8860	5040
	2,2'-Thiobis-Ethanol	3930	3930	3930
	4-Hydroxy-3Methoxy Benzaldehyde	770	770	770
	1,3(2H)-Dione,1H-Isoindole	1490	1490	1490
	Napthol(1,8-CD)Pyran-1,3-Dione,1H,3H	31	692	360
	Sulfonybis-Methane	1560	1560	1560
	2-Methyl-2,4-Pentanediol	2660	2660	2660
68	Di-n-Butylphthalate	0	996	60
	2-[2-(2-Ethoxy-ethoxy)Ethoxy]-Ethanol	1560	1560	1560
	9,10-Anthracenedione	750	750	750
	Isoindole-1,3(2h)-Dione,3A,4,7,7A-Tetrah	1630	1630	1630
	Triphenyl-Phosphineoxide	2390	2390	2390
	2-Phenyl-2-01-Propan	226	402	314
	1,2-Dicarboxylic Acid Anhydride Cyclohex	1030	1030	1030
	Alcanol	1020	1020	1020
66	Bis(2-Ethylhexyl) Phthalate	0	10000	776
71	Dimethyl Phthalate	0	2200	511
	Methyl Acetophenone	0	131	66
69	D-n-Octyl Phthalate	13	31	22
19	2-Chloroethyl Vinyl Ether	0	1100	35
43	Bis(2-Chloroethoxy)Methane	0	25	8
17	Bis(Chloromethyl) Ether	0	250	125

TABLE 5-9 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE COMPOSITE OF DATA SOURCES (CONTINUED)

POLL. #	POLLUTANT NAME	OVERALL-COMPOSITE Min.	Max.	Mean
70	Diethyl Phthalate	0	2100	377
67	Butyl Benzyl Phthalate	0	490	103
	2-Ethyl-1,4-Dimethyl-Benzene	965	965	965
510	Styrene	180	43000	7632
	1,3-Diamino-4-Methyl Benzene	2480	2480	2480
	1,4-Diamino-Benzene	1940	1940	1940
	1,2-Diamino-Benzene	835	835	835
	Benzamide	1500	1500	1500
	4-Hydroxy-4-Methyl-2-Pentanone	710	76000	38355
	Ethanol	42	42	42
	Bis(2-Chloroethoxy) Ethane	13	13	13
	1,1'-Oxybis-2-Ethoxy Ethane	460	460	460
	Methane, Thiobis	47	47	47
585	N,N-Diemethyl Foramide	0	15000	7500
	2,4-Diemethyl Heptane	150	150	150
	2,3,5-Trimethyl Hexane	29	29	29
	4-Ethyl-2-Methyl Hexane	160	160	160
91	Chlordane	200	200	200
112	PCB-1016	629	629	629
	MCPP	6	6	6
	TEPP	665	1193	929
2	Acrolein	0	3000000	180604
515	Ethyl Ether	0	14000	4372
8	1,2,4-Trichlorobenzene	0	29000	4068
571	O-Cresol	5	24000	2259
509	Alpha-Terpineol	0	121	18
506	N-Dodecane	0	62	9
513	P-Cymene	0	17	11
936	Thioxanthone	0	286	50
554	Vinyl Acetate	0	17	11
523	N-Tetracosane	0	153	28
18	Bis(2-Chloroethylether)	0	12	10
580	1,2,3,4-Diepoxybutane	0	338	43
578	2,3-Dichloro-Aniline	1150	1150	1150
502	2-Amino Naphthalene	942	942	942
	2-Methoxy Aniline	515	515	515
	2-Methyl Benzenesulfonamide	114	114	114
	2-Pyridinamine	560	560	560
	4-Ethyl-Morpholine	520	520	520
	1,1,7-Trimethyl Bycyclo(2,2,1)Hept-2-ene	17300	17300	17300
	n-Alkanes(c)*	9540	9540	9540
	2,2,4,6,6-Pentamethyl-Heptane	4760	4760	4760
	Heptadecane	575	5440	3010
	n-Alkanes(A)*	3380	3380	3380
	n-Alkanes(D)*	3740	3740	3740
	n-Alkanes(B)*	2700	2700	2700

TABLE 5-9 ORGANIC COMPOUNDS FOUND IN RAW LEACHATE COMPOSITE OF DATA SOURCES (CONTINUED)

POLL. #	POLLUTANT NAME	OVERALL-COMPOSITE		
		Min.	Max.	Mean
	2-Propenylidene-Cyclobutane	75	75	75
106	PCB-1242	300	240000	86767
107	PCB-1254	700	700	700
	Tetrahydrofuran	4000	600000	137875
538	1,2-Dibromoethane	2200	19000	9733
	2-Methyl-2-Butanol	71000	71000	71000
	2-Butanol	20000	490000	148000
9	Hexachlorobenzene	0	10000	5000
12	Hexachloroethane	0	10000	5000
52	Hexachlorobutadiene	0	30000	15000
933	1,2,4,5-Tetrachlorobenzene	10000	10000	10000
R071	P-Chloroaniline	1600	1600	1600
921	Pentaclorobenzene	20000	20000	20000
	Bromochloromethane	1E+05	130000	130000
48	Bromodichloromethane	0	360	180
533	Carbon Disulfide	0	2500	574
505	Dibenzofuran	0	32	11
80	Fluorene	0	38	13
547	Isobutyl Alcohol	1000	1000	1000
3	Acrylonitrile	3	6	4
527	1,4-Dioxane	400	80000	23717
104	Gamma-BHC	7800	7800	7800
102	Alpha-BHC	5400	5400	5400
	2-(2-Ethoxyethoxy) Ethanol	0	1210	605

NOTES:

(1)- All units in ug/l
(2)- Zero (0) indicates pollutant was analyzed for and not detected
(3)- No value indicates pollutant was not analyzed
(4)- Percent of Sites where pollutant was detected

TABLE 5-10. MOST FREQUENTLY FOUND ORGANIC COMPOUNDS IN LEACHATES

	No. Detects/No. Samples(1)			
Pollutant	ORD/HWERL	Wisconsin Study	EPA-ITD	NEIC
Methylene Chloride	13/13	20/24	4/12	11/13
Toluene	13/13	22/24	5/12	16/18
Benzene	12/13	18/24	2/12	12/18
Ethylbenzene	10/13	14/24	4/12	13/18
Phenol	13/13	17/24	0/12	18/19
Acetone	13/13	--	3/12	14/16
Butanone, 2-	12/13	--	4/12	11/15
Methyl-2-Pentanone, 4-	11/13	--	0/12	16/20
Trichloroethene	11/13	12/24	0/12	12/18
Total Xylenes	11/13	--	--	8/10
Hexanone, 2-	13/13	--	0/12	--
Methylphenol, 4-	12/13	--	--	6/8
O-Cresol (2-Methylphenol)	10/13	--	1/12	4/5
Chloroform	10/13	6/24	0/12	1/1
Dimethylphenol, 2,4-	9/13	2/24	0/12	6/15
Di-N-Butyl Phathalate	9/13	4/24	0/12	1/6
Benzoic Acid	8/13	--	0/12	9/19
Tetrachloroethylene	7/13	9/24	0/12	2/4
Diethyl Phthalate	0/13	17/24	1/12	2/8
Trans-1,2-Dichloroethylene	5/13	14/24	2/12	3/9
Dichloroethane, 1-1	4/13	14/24	1/12	3/6
Alpha-Terpineol	--	--	4/12	--
Isophorone	1/13	12/24	5/12	3/17
Bis(2-Ethylhexyl) Phthalate	1/13	6/24	0/12	1/7
Chlorobenzene	6/13	5/24	0/12	4/8

NOTE:

(1) Data shows the pollutant frequency of occurrence, the number of times the pollutant was detected per the number of samples for which that pollutant was analyzed. Dashes (-) mean either the pollutant was not analyzed for or data was not available for this analysis. Sampling data used to prepare this table are contained in Appendix A.

The organic compounds found at the highest concentrations in each study are summarized in Table 5-11. The NEIC and ORD/HWERL lists are composed of compounds found in concentrations greater than 100,000 μg/l and 20,000 μg/l, respectively, while the other studies list compounds found in concentrations greater than 1,000 μg/l. The compounds with the highest concentrations (i.e., in the ORD/HWERL and NEIC studies) include volatiles, base/neutral extractables, and acid extractables. With the exception of phenol and isophorone, all of the high-concentration compounds in the Wisconsin study are volatile chlorinated compounds. This analysis shows that at certain landfills, extremely high concentrations of toxic materials can be expected in the leachate.

5.2.3 Leachate Flow Generation Rates

Numerous studies have attempted to correlate the rates of leachate generation to landfill size (volume of wastes or surface acreage), climatic factors (net precipitation), geographic location, and landfill design. Generally, these efforts have been unsuccessful as is demonstrated by data from the Wisconsin Study presented in Table 5-12, and as illustrated in Figure 5-1.

Studies indicate that leachate generation rates at a given landfill vary greatly from day to day, primarily due to weather conditions. One landfill with flow monitoring reported volumes ranging from 800 to 70,000 gallons per day (gpd). Such variations coupled with the lack of flow monitoring at most landfills makes any estimate of leachate volumes difficult. In lieu of predictions based on landfill size, actual leachate collection ranges from 0 to 94,000 gpd. Volumes less than 100 gpd are insignificant and probably represent intermittent flows. Two landfills reported leachate rates of less than 1,000 gpd (0 and 270 gpd). If these low values are eliminated, 26,500 gpd is the calculated average leachate generation rate. Since these volumes generally are based on estimates rather than actual measurements, 30,000 gpd was assumed to be the average leachate generation rate for an "average" landfill.

5.2.4 Summary

In summary, the following observations can be made about landfill leachate:

- Landfill leachates can contain very high concentrations (>100,000 μg/l) of toxic organic compounds.
- The analytical methods used to identify and quantify organic pollutants in leachate may have an effect on the quantification of the organics found.

TABLE 5-11. ORGANIC COMPOUNDS FOUND AT THE HIGHEST CONCENTRATIONS IN LEACHATE

ORD/HWERL Study (conc. > 20,000 μg/l)	NEIC Study (conc. > 100,000 μg/l)	CLP Database (conc. > 1,000 μg/l)
Phenol Methylphenol, 4- Benzoic Acid Butanoic Acid Pentanoic Acid O-Cresol (2-Methylphenol) Alkanoic Acid Hexanoic Acid Acetone Butanone, 2- (MEK) Benzyl Alcohol Pentanol, 4-Methyl,2- Methylene Chloride Dichlorobenzene, 1,2- Trichloroethane, 1,1,1- Toluene Aniline Phenol, 2,6-bis(1,1-dimethyl-ethyl)-4-Methyl-	Trichloroethane, 1,1,1- Tetrachloroethane, 1,1,2,2- Ethylbenzene Methylene Chloride Tetrachloroethene Toluene Trichloroethene Tetrahydrofuran Butanone, 2- (MEK) Total Xylenes Acetone Acrolein Butanol, 2- Phenol Benzoic Acid Aniline PCB 1242 Bromochloromethane	Phenol Methylphenol, 4- Butanoic Acid Hexanoic Acid Butanone, 2- (MEK) Benzyl Alcohol Bis(2-Ethylhexyl) Phthalate Hydroxy-4-Methyl-2-Pentanone, 4- Methylene Chloride Toluene Total Xylenes Benzene, 1,3-Dimethyl Formamide, N,N-Dimethyl

EPA-ITD Study (conc. > 1000 μg/l)	Wisconsin Study (conc. > 1000 μg/l)	Misc. Subtitle D (conc. > 1000 μg/l)
Acetone Butanone, 2- (MEK) Isophorone Diethyl Ether Methylene Chloride TEPP Ethyl Ether	Phenol Isophorone Chloroethyl Vinyl Ether, 2- Methylene Chloride Trichloroethane, 1,1,1- Trichloroethene Chloroform Dichloroethane, 1,2- Dichloroethane, 1,1- Trans-1,2-Dichloroethene Toluene Benzene Ethylbenzene	Phenol Methylene Chloride

TABLE 5-12. LEACHATE GENERATION WISCONSIN STUDY

Landfill Type	Landfill ID	Landfill Size (acres)	Leachate Removal Rate (gal/acre/day)	Gal/Landfill
Nat. Attenuation	2680	49	0	0
Zone-of-Saturation	572	82	351	28,782
	611	94	1000	94,000
	1099	96	387	37,152
	1678	166	287	47,642
	2484	47	304	14,288
	2822	18	15	270
Clay-lined	2569	30	88	2,640
	2821	24	215	5,160
	2892	10	176	1,760
	2895	29	204	5,916
Retrofit	652	38	875	33,250

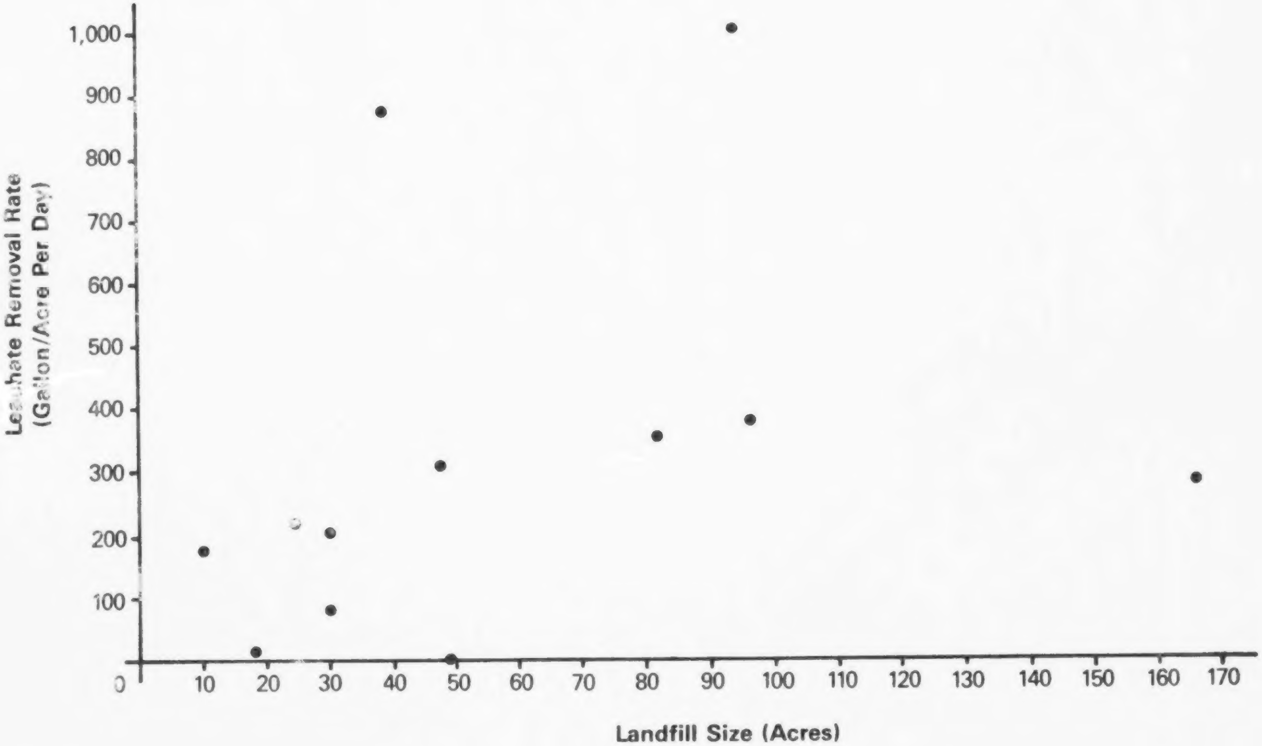

Figure 5-1. Leachate Flow Rates in Wisconsin
(Source: Wisconsin Study, Ref. 7)

- Raw leachates are characterized by high concentrations of BOD5, COD, and TOC.
- Volatile organics frequently are found in leachates, while nonvolatile compounds, if present, are not readily detected.
- Hazardous waste landfill leachates appear to contain more toxic organic compounds than leachate from Subtitle D landfills, but this observation may be due to the list of analytes and/or analytical methodology problems. In terms of COD and TOC, however, there is no apparent difference between hazardous waste and Subtitle D landfills.
- Leachate flow rates vary widely due, in part, to climatic and geological conditions, but are not related to the size of the landfill. An average leachate flowrate is estimated to be 30,000 gpd for an "average" landfill.
- Leachates generally contain high concentrations of aluminum, iron, zinc, manganese, and boron, while the concentrations of toxic metals vary from below detection to over 100 mg/l.

5.3 INCINERATOR SCRUBBER WASTEWATERS

5.3.1 Sources of Incinerator Scrubber Wastewater Data

The characterization of raw incinerator scrubber wastewaters is based solely on the data obtained from the EPA-ITD study sampling efforts. The EPA-ITD study sampled scrubber wastewaters at two incinerators burning RCRA wastes and one incinerator burning both Toxic Substances Control Act (TSCA)-regulated (PCB) wastes and RCRA wastes. Data listings for each facility are presented in Appendix B.

5.3.2 Pollutants in the Incinerator Scrubber Wastewaters

5.3.2.1 Conventional and Nonconventional Pollutants

Chemical characteristics of raw scrubber wastewaters are partially a function of the operation of the scrubber water system. Manufacturers of wet scrubbers indicate that the amount of scrubber water that can be recirculated depends on the amount of solids being removed from the gas stream. In one type of scrubber operation, TSS is maintained between 6,000 and 10,000 ppm, or TDS less than 10 percent. Ammonia often is added to the recirculating water to neutralize the acids from the gases being scrubbed. At other operations, scrubber effluent is treated using lime precipitation prior to recycle. This results in a low TSS concentration in the recirculating scrubber water.

These two different types of operations result in different chemical characteristics of raw scrubber wastewaters, as summarized in Table 5-13 and presented in Appendix B. TSS concentrations range from 2 to 58,000 mg/l; the higher concentrations were associated with systems that operated without lime precipitation. Ammonia concentrations range from 0.1 to 3,100 mg/l. The higher concentrations were the result of ammonia used to neutralize the acids. The pH of most raw scrubber wastewaters is low due to the hydrogen chloride gases generated by burning wastes and removed by the wet scrubbers.

High TDS and chlorides are characteristics of all scrubber wastewaters. The high TDS is caused by the removal of gases containing chloride and SO_2 (producing sulfate in water), the addition of chemicals to neutralize the acids in the stack gases, and the dissolution of solids in the particulates removed by the scrubbers.

5.3.2.2 Toxic Pollutants

Tables 5-14 and 5-15 summarize the metals and organic pollutants in raw scrubber wastewaters. These data indicate that scrubber wastewaters contain high concentrations of metals, but few organic pollutants.

Metals

Table 5-14 shows that scrubber wastewaters can contain high concentrations of aluminum, iron, lead, zinc, mercury, and copper (i.e., 20,000 to 500,000 µg/l). Manganese, boron, molybdenum, tin, titanium, and nickel occur in significant (over 1 mg/l) but lesser concentrations. Potential sources of the metals are the wastes and waste containers being incinerated and the materials that comprise the incinerator and scrubbers. The presence of titanium, which is a corrosion-resistant metal used in scrubber construction, is one example.

The metals concentrations are also a function of the operation of the scrubber water system, with the high concentrations occurring at the facility that recirculates a high TSS and TDS load in the water. The data suggest that a large portion of the metals are associated with the solids being recirculated (i.e., metals contained in the fly ash), but this may not be the case. Since this scrubber water is not treated (i.e., chemical precipitation

TABLE 5-13. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN RAW SCRUBBER WASTEWATERS

	Range of Detected Pollutant(1)(2)		
Pollutant	Minimum	Maximum	Mean
BOD5	18	300	88
COD	110	760	410
TOC	17	630	195
TSS	2	58,000	12,700
TDS	4,007	11,700	6,710
Chloride	2,400	9,000	5,550
O&G	1.0	1.8	1.1
Ammonia-N	0.1	3,100	733
TKN	1.6	200	56
NO_2 and NO_3-N	0.25	3.9	1.7
Fluoride	2.75	400	100
Sulfide	0.1	0.1	0.1
pH (S.U.)	1.2	7.3	
Phenols	0.05	0.22	0.12
Cyanide	0.01	0.02	0.01
TVO	0.1	0.1	0.1
Calcium	440	3,410	1,660
Magnesium	5.16	320	203
Sodium	150	500	330

NOTES:

(1) All concentrations expressed in mg/l, except pH (Standard Units).

(2) Data presented are the results of the EPA-ITD sampling effort of three incinerator scrubber wastewaters. All sampling data for these three facilities are contained in Appendix B.

TABLE 5-14. METALS IN RAW SCRUBBER WASTEWATER

	Range of Detected Metal(1)(2)			Percent of Samples
Metal	Minimum	Maximum	Mean	Where Metal Was Detected
Aluminum	2,130	170,000	48,100	100
Iron	3,400	520,000	164,000	100
Manganese	269	12,000	3,420	100
Boron	260	18,000	4,980	100
Barium	190	6,000	2,070	100
Molybdenum	130	12,000	3,580	100
Antimony	28	4,420	1,500	100
Arsenic	6	3,460	1,040	100
Beryllium	<1	14	4.2	67
Cadmium	12	2,000	600	100
Chromium	45	2,800	970	100
Cobalt	<4	860	282	67
Copper	84	23,000	6,430	100
Lead	88	75,000	21,200	100
Mercury	0.26	318	71	100
Nickel	78	8,300	2,310	100
Selenium	<5	13	6.6	20
Silver	2	58	35	100
Thallium	<10	17	11	17
Tin	<13	4,900	1,580	83
Titanium	59	8,300	2,790	100
Vanadium	4	110	46	100
Yttrium	<10	42	18	33
Zinc	350	660,000	159,000	100

NOTES:

(1) All concentrations expressed in μg/l.

(2) Data presented are the results of the EPA-ITD sampling effort of three incinerator scrubber wastewaters. All sampling data for these three facilities are contained in Appendix B.

TABLE 5-15. ORGANICS IN RAW SCRUBBER WASTEWATER(1)(2)

Compound	Concentration (1)	Number of Samples Where Compound Was Detected
Acetone	65	1
Benzene	61	1
Bromoform	15	1
Fluoranthene	109	1
N-Nitrosodi-N-Propylamine	907	1
Pyrene	326	1
Thioxanthone	4,067	1

NOTES:

(1) All concentrations expressed in µg/l.

(2) Data presented are the results of the EPA-ITD sampling effort of three incinerator scrubber wastewaters. All sampling data for these three facilities are contained in Appendix B.

and clarification) prior to recirculation, a significant amount of dissolved metals may accumulate in the scrubber water.

Organic Compounds

The absence of all but a few organic pollutants in the raw scrubber wastewaters is expected if the RCRA and TSCA incinerators are achieving the required destruction levels. The TOC data support the relative absence of organics except at one facility. In this facility, which recirculates high TSS concentration scrubber water, the TOC concentrations are relatively high; however, the high TOCs may be due to carbon particles in the TSS from fly ash rather than organic compounds, because carbon particles can produce a positive TOC test. None of the raw wastewaters were analyzed for dioxin and furan isomers, but the presence of these toxic organics in the scrubber sludges suggests their presence in the raw scrubber wastewaters. Further discussion of dioxins and furans is presented in Section 6.2.

5.3.3 Scrubber Wastewater Flow Rates

Data for scrubber wastewater discharge (i.e., blowdown from the recirculating scrubber water system) was compiled from four facilities (three facilities sampled during the EPA-ITD sampling program and information obtained from a fourth facility during an engineering visit). Manufacturers recommended that blowdown be controlled by the amount of TSS or TDS in the scrubber water. However, the scrubber systems sampled during this study show a wide range of wastewater blowdown rates and water used for scrubbing as shown in Table 5-16.

These data show an average scrubber blowdown rate of 1.76 gal/lb of waste incinerated. In addition to being affected by the amount of fly ash particulates (TSS) and acid (as TDS) removed from the stack gases, the blowdown rate depends on the level of TSS maintained in the scrubber water system (Section 5.3.2), the chemicals used for scrubber water treatment, and the operation of the scrubber wastewater (blowdown) treatment system, if one is in-place.

Manufacturers' data compiled by Mitre Corporation (Ref. 9) for hazardous waste incinerator types and capacities are summarized in Table 5-17.

The weighted average is 2,200 lb/hour or 53,000 lb/day, based on a 24-hour operating day. Coupled with the average scrubber wastewater blowdown rate (1.76 gal/lb waste), the average scrubber wastewater discharge per facility is estimated to be 93,000 gpd.

TABLE 5-16. SCRUBBER WASTEWATER BLOWDOWN RATES (1)

	Blowdown	
	% of recirculating flow	gal/lb. waste incinerated
Site G	--	0.65
Site H	9.6	3.90
Site I	2.2	0.46
Site X	15	2.02

Note: Sites G, H, and I were sampled during the EPA-ITD sampling program. An engineering site visit was conducted at Site X.

TABLE 5-17. SUMMARY OF HAZARDOUS WASTE INCINERATOR TYPES AND CAPACITIES (1)

Incinerator Type	Average or Median Capacity (lb/hr)	Number of Units
Liquid Injection	1,600	93
Fixed Hearth	810	48
Rotary Kiln	1,600	34
Fluidized Bed	31,000	5
		180

NOTE:

(1) Data supplied by Mitre Corporation (Reference 9).

Three of the four facilities that provided data during this study are large incinerators. Their average flow is 350,000 gpd, which is well above the projected industry average of 93,000 gpd.

5.3.4 Summary

In summary, the following observations can be made about raw incinerator scrubber wastewaters:

- Chemical characteristics of raw scrubber wastewater are partially a function of the scrubber system operation. High ammonia concentrations are found in systems that use ammonia to neutralize acids. TSS concentrations are high in systems that do not use lime precipitation.
- Raw scrubber wastewaters are characterized by low pH, high TDS, and high chlorides.
- Scrubber wastewaters contain high concentrations of metals. The metals detected at the highest concentrations include aluminum, iron, lead, zinc, mercury, and copper.
- Scrubber wastewaters contain few organic pollutants.
- An average scrubber wastewater discharge is estimated to be 93,000 gpd based on flow measurements and manufacturers' data.

5.4 AQUEOUS HAZARDOUS WASTE

The following sections summarize the pollutants found in raw aqueous hazardous wastes. Data were obtained from two sources, as indicated in the summary tables. Individual listings of the data are presented in Appendix C

5.4.1 Sources of Raw Waste Data

The primary source for analytical data characterizing aqueous hazardous wastes is the 1986-87 EPA-ITD study sampling effort. Four aqueous hazardous waste treatment facilities were sampled during this program. The aqueous treaters accepted and treated inorganic industrial wastes (plating baths, pickle liquors); organic wastes (food and pharmaceutical manufacturing, solvent reclaiming, detergent manufacturing); oil wastes; tank washings; leachates (hazardous and Subtitle D landfills); brines; scrubber wastewaters; miscellaneous waste acids; and caustics.

The EPA-ITD study sampling data are supplemented by analytical data obtained from two aqueous treaters sampled during an OSW study to support OSW's Land Disposal Restriction Rules. While the EPA-ITD study analyzed the wastewaters for the Appendix IX pollutants in addition to conventionals and nonconventionals, the OSW samples were only analyzed for 15 toxic metals, 29 volatile organic compounds, 29 extractables, and selected conventional and nonconventional pollutants. QA/QC data are available for both the EPA-ITD and OSW sampling efforts.

5.4.2 Pollutants in the Raw Aqueous Hazardous Waste

5.4.2.1 Conventional and Nonconventional Pollutants

Table 5-18 summarizes the conventional and nonconventional pollutant data from the previously discussed sources. The data show that aqueous hazardous wastes contain high concentrations of BOD_5, COD, and TOC (mean concentrations of BOD_5, COD, and TOC are in the range of 1,500 to 15,000 mg/l). These data indicate that these facilities have a wide range of concentrations for these pollutants. In addition, the individual sample data presented in Appendix C show that the concentrations of these pollutants vary widely from day to day. This is due to variations in waste types being processed by these facilities.

The fact that the raw wastes treated at aqueous hazardous treatment facilities are high-strength wastes also is reflected in the presence of other pollutants, specifically TSS, TDS, total solids, ammonia, TKN, oil and grease, and cyanides. As with BOD_5, COD, and TOC, the concentrations of these pollutants are highly variable, and the overall mean concentrations are high.

5.4.2.2 Toxic Pollutants

Metals

Metals data for the raw aqueous hazardous wastes are summarized in Table 5-19. Like the conventional and nonconventional pollutant data, the metals data show a wide range of concentrations among facilities and from day to day. Metals, including aluminum, iron, boron, copper, zinc, chromium, lead, cadmium, nickel, and manganese, were found at concentrations as high as 11,000 mg/l. Copper, chromium, cadmium, lead, nickel, and zinc are common metals with numerous industrial uses, which accounts for their presence in all raw waste samples. Aluminum, iron, boron, and manganese are also present in many industrial wastewaters. Less commonly used industrial metals such as beryllium, selenium, silver, thallium, tin, vanadium, cobalt, arsenic, and yttrium were found at lower concentrations.

TABLE 5-18. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN AQUEOUS HAZARDOUS WASTES - SUMMARY(1)

Pollutant	EPA-ITD Study				OSW Study				Overall	
	Minimum	Maximum	Mean	No. of Samples	Minimum	Maximum	Mean	No. of Samples	Mean	No. of Samples
BOD_5	330	3,720	2,000	8	--	--	--	--	2,000	8
COD	4,160	14,100	8,360	8	11,000	70,000	39,300	3	16,800	11
TOC	450	1,600	965	7	52	19,000	4,180	14	3,115	21
Total Solids	--	--	--	--	200,000	250,000	223,000	3	223,000	3
TDS	2,700	70,400	23,400	8	10,000	170,000	107,000	3	46,200	11
TSS	130	9,240	1,570	8	46,000	240,000	115,000	3	32,500	11
Chloride	300	11,500	4,720	8	--	--	--	--	4,720	8
O&G	4.2	1,390	385	8	2,600	18,000	11,200	3	3,330	11
Total Organic Halides	--	--	--	--	0	0.36	0.144	15	0.144	15
Ammonia(2)	8.1	1,000	475	8	20	100	52	3	360	11
TKN(2)	2.5	1,210	382	8	--	--	--	--	382	8
NO_2 and NO_3-N					--	--	--	--		
Fluoride	2.3	500	138	8	19	52	35	3	110	11
Sulfide										
Phenols	1.4	18.7	8.64	8	--	--	--	--	8.64	8
Cyanide	0.1	5.0	1.18	8	<20	450	235	2	48	10
Silica	--	--	--	--	0.4	1.32	0.81	3	0.81	3
TVO					--	--	--	--		
Calcium	59	711	389	8	--	--	--	--	389	8
Magnesium	5.0	136	48	8	--	--	--	--	48	8
Sodium	527	6,500	2,270	8	--	--	--	--	2,270	8

NOTES:

(1) All concentrations expressed in mg/l, except total organic halides (weight %), and silica (weight %).

(2) Evidence of the analytical problems discussed in Section 5.1 can be seen here were ammonia is reported higher than TKN.

Table 5-19. Metals in Aqueous Hazardous Wastes - Summary(1)

Pollutant	EPA-ITD Study				OSW Study				Overall	
	Minimum	Maximum	Mean (2)	% Detected (3)	Minimum	Maximum	Mean (2)	% Detected (4)	Mean (6)	No. of Samples (7)
Aluminuum	730	63,400	29,300	100	--	--	--	--	29,300	8
Iron	3,780	11,200,000	2,560,000	100	--	--	--	--	2,560,000	8
Manganese	380	68,400	16,900	100	--	--	--	--	16,900	8
Boron	8,800	63,500	26,300	100	--	--	--	--	26,300	8
Barium	205	1,100	522	100	<10,000	12,000	(5)	8	1,800	9
Molybdenum	608	2,290	1,080	100	--	--	--	--	1,080	8
Antimony	22	2,140	477	100	<10,000	40,000	(5)	8	4,870	9
Arsenic	<25	1,051	248	86	--	<1,000	--	0	248	6
Beryllium	<1	16	14	25	--	<2,000	--	0	14	2
Cadmium	16	1,190	363	100	3,900	225,000	58,800	53	29,600	16
Chromium, total	108	99,900	35,600	100	12,000	2,581,000	1,205,000	100	798,000	23
Chromium, hex.	--	--	--	--	50	893,000	408,000	100	408,000	12
Cobalt	<50	1,310	547	62	--	--	--	--	547	5
Copper	296	969,000	221,000	100	72,000	1,500,000	294,000	100	269,000	23
Lead	<200	17,100	6,940	75	1,100	212,000	60,900	67	25,000	16
Mercury	1.1	92	25	100	--	<1,000	--	0	25	8
Nickel	252	93,700	22,500	100	4,300	16,330,000	1,992000	100	1,307,000	23
Selenium	<5	3,270	685	62	--	<10,000	--	0	685	5
Silver	2.2	525	177	62	--	<2,000	--	0	177	5
Thallium	--	<10	--	0	--	<10,000	--	0	0	0
Tin	<40	3,520	2,000	50	--	--	--	--	2,000	4
Titanium	<50	2,280	806	75	--	--	--	--	806	6
Vanadium	47	641	227	75	--	--	--	--	227	6
Yttrium	<10	430	206	38	--	--	--	--	206	3
Zinc	334	6,570,000	1,330,000	100	3,900	1,700,000	194,000	100	589,000	23

Table 5-19. Metals in Aqueous Hazardous Wastes - Summary(1) (Continued)

NOTES:

(1) All concentrations expressed in µg/l.

(2) Mean of detected values; values reported less than the detection limit not included in mean calculation

(3) % detected in the EPA-ITD Study based on sampling data from four sites (total of 8 samples). All sampling data are contained in Appendix C.

(4) % detected in the OSW Study was based on sampling results from two facilities. The number of samples for which a given pollutant was analyzed ranged from 12 to 15. Sampling data are contained in Appendix C.

(5) Mean not presented when the pollutant was measured at higher than the detection limit in only one sample.

(6) The overall mean was calculated using the mean concentrations from the two studies using the following formula:

$$\text{Overall mean} = \frac{\Sigma\ (\text{mean} \times n)}{\Sigma\ n}$$

(7) Total number of samples in the combined studies in which the pollutant was detected.

Organic Compounds

Table 5-20 summarizes the organic pollutants found in the raw aqueous hazardous wastes. Like the other pollutants, the organic compounds are found in a wide range of concentrations and in many cases, at high concentrations. Common organic solvents such as acetone, 2-butanone (MEK), methylene chloride, benzene, 1,1,2,2-tetrachloroethane, and toluene were found in the highest concentrations. These compounds were also among the most frequently detected organic pollutants (i.e., found in 38 to 75 percent of the samples taken in the HWT study. In addition, several extractable organics: thioxanthone, 2-chloronaphthalene, alpha-terpineol, phenol, and 4-chloro-3-methylphenol, were found in high concentrations (i.e., as high as 28,000 μg/l), but usually in less than half of the samples. The most commonly found extractable compound was di-n-butyl phthalate, which was detected in 63 percent of the samples tested. Phenol was detected in two of the three OSW study samples, but in only two of eight EPA-ITD study samples.

5.4.3 Aqueous Hazardous Waste Flow Rates

Flow data for aqueous hazardous waste treatment facilities were compiled from numerous sources. The HWT study sampling efforts, presampling visits, and telephone contacts yielded flow rates from 12 facilities. These ranged from 13,600 to 117,000 gpd, with an average of 59,400 gpd. The "1985 Survey of Selected Firms in the Hazardous Waste Management Industry" (Ref. 11) indicated that 34 chemical/biological treatment facilities treated 1,567,000 wet metric tons of hazardous wastes in 1985. Assuming 300 days/year of operations and 8.34 lb/gal, the average flow rate is 40,600 gpd. If these two estimates are combined, a flow weighted average of 45,500 gpd is calculated for a typical aqueous hazardous waste treatment facility.

5.4.4 Summary

In summary, the following observations can be made about the toxic pollutants in raw aqueous hazardous wastes and industry flow rates:

- Aqueous hazardous wastes contain high concentrations of BOD_5, COD, and TOC.

- Both metals and organic compounds were found in a wide range of concentrations and, in some cases, at very high concentrations.

TABLE 5-20. ORGANIC POLLUTANTS IN AQUEOUS HAZARDOUS WASTES - SUMMARY(1)

Pollutant	EPA ITD Study				OSW Study				Overall	
	Minimum	Maximum	Mean (2)	% Detected (3)	Minimum	Maximum	Mean (2)	% Detected (4)	Mean (6)	No. of Samples (7)
Volatiles										
Acetone	<50	1,719,690	254,177	63	-	22,000	(5)	33	228,380	9
Benzene	<10	17,171	2,241	75					2,241	8
Butanone, 2- (MEK)	<50	156,973	48,225	63					48,225	8
Carbon Tetrachloride	<10	329	54	25					54	8
Chlorobenzene	<10	650	94	25					94	8
Chloroform	<10	1,151	285	38	<10	110	18	8	125	20
Dichloroethane, 1,1-	<10	839	150	25	<10	340	64	27	98	20
Dichloroethane, 1,2-	<10	263	62	38					62	8
Dichloroethene, 1,1-	<10	1,517	198	13					198	8
Diethyl Ether	<50	81	54	13					54	8
Dibromoethane, 1,2- (EDB)	<10	20	11	13					11	8
Ethylbenzene	<10	934	378	63	<10	200	49	40	181	20
Hexanone, 2-	<10	200	57	25					57	8
Methylene Chloride	<10	4,094	1,388	75	<10	63,000	6,875	20	4,966	23
Tetrachloroethane, 1,1,2,2-	<10	108,716	13,635	38					13,635	8
Tetrachloroethene	<10	3,043	407	25	<10	2,300	200	33	279	21
Toluene	<10	115,068	16,281	75	<10	2,300	298	47	6,110	22
Trans-1,2-Dichloroethene	<10	190	55	38	<10	25	11	8	29	20
Trichloroethane, 1,1,1-	<10	4,163	1,063	75	<10	9,400	1,182	40	1,139	22
Trichloroethane, 1,1,2-	<10	332	52	25	<10	46	13	8	29	20
Trichloroethene	<10	5,060	673	63	<10	1,100	123	20	333	21
Vinyl Acetate	<10	814	111	13					111	8
Extractables										
Alpha-Terpineol	<10	5,701	1,446	38					1,446	4
Isophorone	<10	2,372	501	38					501	6
N-Dodecane (N-C12)	<10	47	19	13					19	4

TABLE 5-20. ORGANIC POLLUTANTS IN AQUEOUS HAZARDOUS WASTES - SUMMARY(1) (CONTINUED)

	EPA ITD Study				OSW Study				Overall	
Pollutant	Minimum	Maximum	Mean (2)	% Detected (3)	Minimum	Maximum	Mean (2)	% Detected (4)	Mean (6)	No. of Samples (7)
N-Hexadecane (N-C16)	<10	2,969	869	25					869	5
N-Docosane (N-C22)	<10	5,056	1,019	13					1,019	5
Benzoic Acid	<10	1,129	540	25					540	4
P-Cresol	<10	64	24	25					24	4
O-Cresol	<10	1,703	222	13					222	8
Thioxanthone	<10	28,625	7,996	25					7,996	7
Di-N-Butyl Phthalate	<10	1,059	220	63					220	5
Pentachlorophenol	<50	117	67	13					67	4
Phenol	<24	4,442	1,560	75	3,900	4,400	4,150	67	2,208	8
Chlorophenol, 2-	<10	10	10	13					10	4
Chloronaphthalene, 2-	<10	16,480	3,519	25					3,519	6
Chloro-3-Methylphenol, 4-	<10	3,397	1,322	25	--	3,100	(5)	33	1,678	5
Benzyl Alcohol	<10	2,601	795	38					795	8
Hexanoic Acid	<10	2,443	928	38					928	5
Isobutyl Alcohol	<10	187	35	25					35	8
Methyl Methacrylate	<10	12	10	13					10	8
Bis (2-Ethylhexyl) Phthalate	<10	380	129	38					129	6
Fluorene	<10	20	13	13					13	4
Naphthalene	<10	285	75	25					75	5
Styrene	<10	1,003	224	38					224	6
Diphenylhydrazine, 1,2-	<10	26	19	13					19	4
Dinitrotoluene, 2,4-	<10	192	57	25					57	4
Bis (2-Chloroethyl) Ether	<10	1,391	286	13					286	5
Diphenylamine	<10	22	13	13					13	4
Hexachloro-1,3-Butadiene	<10	599	157	13					157	4
Hexachlorobenzene	<10	14	11	13					11	4
Hexachloroethane	<10	132	41	13					41	4
Dichlorobenzene, 1,2-	<10	106	34	13					34	4
Methylnaphthalene, 2-	<10	2,444	358	13					358	7

TABLE 5-20. ORGANIC POLLUTANTS IN AQUEOUS HAZARDOUS WASTES - SUMMARY(1) (CONTINUED)

	EPA ITD Study				OSW Study				Overall	
Pollutant	Minimum	Maximum	Mean (2)	% Detected (3)	Minimum	Maximum	Mean (2)	% Detected (4)	Mean (6)	No. of Samples (7)
N-Octadecane (N-C18)	<10	449	98	20					98	5
N-Decane (N-C10)	<10	670	208	33					208	6
Butyl Benzyl Phthalate	<10	785	165	20					165	5
Nitrophenol, 2-	<20	202	66	25					66	4
N-Nitrosodi-N-Butylamine	<10	200	37	14					37	7
P-Cresol	<10	64	24	50					24	4

NOTES:

(1) All concentrations expressed in µg/l.

(2) Mean of detected values; values reported less than the detection limit not included in mean calculation.

(3) % detected in the EPA-ITD Study based on sampling data from four sites (total of 8 samples). All sampling data are contained in Appendix C.

(4) % detected in the OSW Study was based on the sampling results from two facilities. The number of samples for which a given pollutant was analyzed ranged from three to fifteen. Sampling data are contained in Appendix C.

(5) Mean not presented when the pollutant was measured at higher than the detection limit in only one sample.

(6) The overall mean was calculated using the mean concentrations from the two studies using the following formula:

$$\text{Overall mean} = \frac{\Sigma\ (\text{mean x n})}{\Sigma\ n}$$

(7) Total number of samples in the combined studies in which the pollutant was detected.

- The metals found the most frequently and at the highest concentrations were chromium, copper, nickel, zinc, iron, aluminum, boron, and manganese.

- The organics found the most frequently and at the highest concentrations were industrial solvents.

- The wide range of concentrations of the toxic pollutants in the raw waste samples can be attributed to the high variability of wastes received and treated by these facilities.

- Flow rates at facilities treating aqueous hazardous waste averaged 45,500 gpd.

6. CONTROL AND TREATMENT TECHNOLOGIES

This section discusses the control and treatment technologies employed in each of the hazardous waste treatment (HWT) industry subcategories. The information presented in this section has been complied from several sources. The effluent and residuals data corresponding to specific treatment systems were obtained from the U.S. Environmental Protection Agency - Industrial Technology Division (EPA-ITD) study, as well as other EPA sampling efforts. Discussions of other treatment and disposal methods employed by the industry were obtained from presampling visits, telephone contacts, and published reports.

Because of the variability in the strength of the raw wastes and the long detention times of the treatment systems, it is difficult to estimate percent pollutant reductions, especially with only two consecutive days of samples. Therefore, the percent reduction data presented in this section cannot be considered accurate. Many data pairs actually showed negative removals. In these instances, the percent removals were assumed to be zero.

6.1 LEACHATE TREATMENT

Leachate treatment systems are composed of various combinations of unit processes, each highly individualized to meet the regulatory requirements imposed by the receiving Publicly-Owned Treatment Works (POTW) or the NPDES permitting authority. For example, some POTWs only require aeration to oxygenate the leachate, while other POTWs require, in addition to aeration, combinations of biological treatment, air stripping, and carbon adsorption prior to discharge. These extremes reflect the diversity in approaches to the treatment of leachate found in the HWT industry.

6.1.1 Sources of Data

The primary source of data regarding leachate treatment technologies and the only source of effluent data is the EPA-ITD study effort, which included six leachate treatment facilities. Telephone contacts supplied information on other discharge technologies such as recirculation, solidification, and contract hauling. Only facilities that provide treatment and discharge of leachate actually were visited and/or sampled.

6.1.2 Subtitle D and Subtitle C Facilities

Little information is available at this time regarding the differences in treatment technologies employed for treatment of leachate from hazardous versus Subtitle D landfills; however, of the 10 hazardous waste landfills for which information is available (6 landfills from the EPA-ITD sampling program and 4 from telephone contacts), 5 have on-site wastewater treatment plants, 3 contract haul their leachate to a commercial aqueous treater, 1 deep well injects, and 1 solidifies and reburies the leachate. Of the 5 with on-site wastewater treatment systems, two also serve in a commercial aqueous hazardous waste treater capacity.

Discharge to a POTW or hauling to a commercial aqueous treater are the primary leachate management methods for Subtitle D landfills. As mentioned previously, the treatment technologies employed by those discharging to a POTW range from aeration to sophisticated advanced treatment systems. Specific leachate treatment systems, their technologies, and effluent quality will be discussed in the following sections.

6.1.3 Preliminary Treatment

6.1.3.1 Treated Effluent Data

Conventional and Nonconventional Pollutants

Three landfills included in the EPA-ITD study provided only aeration of their leachate prior to discharge to POTWs. The landfills were municipal landfills and aeration was employed to protect the sewers from hydrogen sulfide and methane gas buildup rather than to provide biological treatment. Consequently, little BOD$_5$ and COD reduction were observed at two of the facilities. The third facility has an aerated lagoon, which provided a 45 percent reduction in BOD$_5$ and 50 percent reduction in COD. Some TOC and ammonia reduction was observed in all of the systems. The average effluent concentrations from these three landfills are summarized in Table 6-1.

Metals

Aluminum, iron, manganese, boron, and zinc were found in concentrations higher than 1,000 µg/l in the raw leachate feed to the aeration ponds. Mean reductions of these metals ranged from 0 to 46 percent. The metals showing the highest average percent reductions were iron, aluminum, and zinc.

TABLE 6-1. CONCENTRATIONS OF POLLUTANTS IN PRELIMINARY TREATMENT SYSTEM (AERATED LAGOON) EFFLUENTS - LEACHATE SUBCATEGORY

Pollutant	Units	Effluent Concentration Minimum	Effluent Concentration Maximum	Effluent Concentration Mean	Mean % Removal(1)
BOD5	mg/l	180	2,520	1,270	15
COD	mg/l	992	7,860	3,890	18
TOC	mg/l	270	3,670	1,120	18
TSS	mg/l	16	3,080	658	23
Ammonia	mg/l	39	197	118	25
TKN	mg/l	50	301	163	19
Oil & Grease	mg/l	4.1	498	98	44
Aluminum	µg/l	<100	1,720	745	46
Iron	µg/l	10,700	205,000	70,000	45
Manganese	µg/l	5,130	19,300	10,200	22
Boron	µg/l	1,220	5,070	2,710	19
Zinc	µg/l	338	3,660	1,050	39
Nickel	µg/l	67	298	184	13
Barium	µg/l	153	271	210	24
Cadmium	µg/l	<5	<5	<5	(2)
Chromium	µg/l	15	87	45	37
Cobalt	µg/l	75	91	83	20
Copper	µg/l	<25	41	28	1
Lead	µg/l	<200	<200	<200	(2)
Molybdenum	µg/l	<100	<100	<100	(2)
Titanium	µg/l	<50	81	55	15
Vanadium	µg/l	<50	<50	<50	13
Yttrium	µg/l	<50	<50	<50	5
Antimony	µg/l	<20	<20	<20	(2)
Arsenic	µg/l	45	56	50	23
Mercury	µg/l	<0.2	<0.2	<0.2	(2)
Acetone	µg/l	<50	7,772	2,564	29
Alpha-Terpineol	µg/l	65	367	154	6
Benzyl Alcohol	µg/l	<10	64	24	0
Bromoform	µg/l	<10	62	19	0
Diethyl Phthalate	µg/l	<10	26	14	8
Isophorone	µg/l	<10	245	70	51
Methylene Choride	µg/l	<10	17	11	64
Butanone, 2- (MEK)	µg/l	<50	6,600	2,070	49
Hexanone, 2-	µg/l	<10	57	18	0
Carbon Tetrachloride	µg/l	<10	23	12	0
Methyl Methane-sulfonate	µg/l	<10	557	119	0
Dimethyl Sulfone	µg/l	<10	12	10	0
Benzene	µg/l	<10	<10	<10	27
Diethyl Ether	µg/l	<50	<50	<50	60

TABLE 6-1. CONCENTRATIONS OF POLLUTANTS IN PRELIMINARY TREATMENT SYSTEM (AERATED LAGOON) EFFLUENTS - LEACHATE SUBCATEGORY (Continued)

Pollutant	Units	Effluent Concentration Minimum	Effluent Concentration Maximum	Effluent Concentration Mean	Mean % Removal(1)
Ethylbenzene	µg/l	<10	<10	<10	63
O-Cresol	µg/l	<10	<10	<10	14
P-Cymene	µg/l	<10	<10	<10	14
Toluene	µg/l	<10	<10	<10	48
Trans-1,2-Dichloroethane	µg/l	<10	<10	<10	30
Vinyl Chloride	µg/l	<10	<10	<10	32
Dichloroethane, 1,1-	µg/l	<10	<10	<10	14
Naphthalene	µg/l	<10	<10	<10	8
Diepoxybutane, 1,2,3,4-	µg/l	<10	<10	<10	32
Dichlorophenol, 2,6-	µg/l	ND	65	--	(3)

ND = Not detected

NOTES:

(1) Mean % removal was calculated using the EPA-ITD sampling data for individual facilities using the following formula:

$$\text{Mean \% Removal} = \frac{\sum_{i}^{n} \frac{(\text{mean influent} - \text{mean effluent})}{\text{mean influent}} \times 100}{n}$$

Mean influent and mean effluent concentrations were calculated for each of the landfills with preliminary treatment (sites D, E, and F). This data is contained in Appendix A. Influent refers to raw leachate and effluent to final treated effluent, in this case effluent from the aerated lagoon. For those pollutants where effluent concentrations were reported less than the detection limit (for example benzene, <10 µg/l) the detection limit (10 µg/l) was used in the calculation.

n = 3, the number of facilities with preliminary treatment.

(2) % removals were not reported for these pollutants since both influent and effluent concentrations are below the detection limits.

(3) 2,6 dichlorophenol was detected in one effluent sample and in none of the influent samples, therefore a percent removal is not reported for this pollutant.

Organic Pollutants

As discussed in Section 5, there is evidence to indicate that the analytical methods used for the analysis of organic compounds may not detect and identify and/or completely quantify many of the Appendix IX organics. Whether this problem also occurs in leachate after treatment is not known because there are no treated leachate data from other studies for comparison. However, the organic compounds detected in treated leachate may represent only a portion of the Appendix IX compounds actually present.

Although the majority of the toxic organic compounds identified in the raw and aerated leachate were volatiles, it is difficult to determine the extent of treatment provided by the aerated lagoons. The reasons are again the variable influent concentrations and the detention times, which make it difficult to pair treated and untreated concentrations. Table 6-1 presents the average effluent concentrations for the three aerated lagoons. Both acetone and 2-butanone are present in the treated effluent in concentrations exceeding 1,000 µg/l.

In summary, it appears that little treatment is achieved in preliminary treatment systems. The only metals that show significant reductions in concentration are aluminum, zinc, and iron. This is a result of only limited precipitation/sedimentation of the balance of metals occurring in the aerated lagoons. Acetone and 2-butanone are present in aerated lagoon effluents with mean concentrations exceeding of 1,000 µg/l.

6.1.3.2 Residuals Data

Table 6-2 summarizes data for metals and organics found in the sludge from the one aerated lagoon at which a sample could be collected. Aluminum and iron, the metals with the highest percent removals, were also the metals with the highest concentrations in the sludge. Only one organic compound, acetone, was detected in the sludge; however, only one sludge sample was collected compared to six treated effluent samples. Therefore, this single sludge may not be representative of organic compounds found in aerated lagoon sludges.

6.1.4 Biological Treatment

6.1.4.1 Treated Effluent Data

One facility sampled during the EPA-ITD study provided biological treatment for leachate. The raw leachate to this activated sludge system was of low strength due to dilution by groundwater.

TABLE 6-2. CONCENTRATIONS OF POLLUTANTS IN PRELIMINARY TREATMENT SYSTEM SLUDGE - LEACHATE SUBCATEGORY(1)

Pollutants	Units(2)	Sludge Sample
Aluminum	mg/kg	4640
Barium	mg/kg	35
Boron	mg/kg	6
Cadmium	mg/kg	1
Chromium	mg/kg	16
Cobalt	mg/kg	6
Copper	mg/kg	16
Iron	mg/kg	14,900
Lead	mg/kg	11
Manganese	mg/kg	169
Molybdenum	mg/kg	<5
Nickel	mg/kg	21
Tin	mg/kg	7
Titanium	mg/kg	317
Zinc	mg/kg	225
Antimony	mg/kg	<2
Arsenic	mg/kg	35
Mercury	mg/kg	0.4
Acetone	µg/l	161

NOTES:

(1) Preliminary treatment in the leachate subcategory is aerated lagoons. Sludge sample collected from aerated lagoon.

(2) Mg/kg reported on a wet sludge basis.

Conventional and Nonconventional Pollutants

The activated sludge system included the addition of powdered activated carbon. No reduction in BOD$_5$, COD, or TOC was observed. The effluent BOD$_5$ concentration averaged 39 mg/l, as shown in Table 6-3. Small reductions in the ammonia and TKN concentrations were observed.

Metals

The only two metals that were found in the raw leachate in concentrations greater than 1,000 µg/l were iron and manganese. Average reductions of these and other metals ranged from 0 to 69 percent (for iron). Only the effluent concentration of iron remained over 1,000 µg/l, while the average effluent concentrations of all other metals except manganese, aluminum, and boron were below 100 µg/l.

Organic Pollutants

No organic pollutants were detected in the activated sludge system effluent; however, only two compounds, bis(2-chloroethyl) ether and thioxanthone, were found in the raw leachate and at very low concentrations.

In summary, the performance of biological systems for treatment of leachate cannot be adequately evaluated due to: (1) having data from only one treatment system employing biological treatment, and (2) the low strength of the raw leachate treated by the system. Further, employing solely biological treatment is not a common practice for leachate. Section 6.1.5 discusses the more advanced leachate treatment systems.

6.1.4.2 Residuals Data

Table 6-4 lists the metals that were found to be concentrated in the sludge waste from the biological system. Although lead, copper, chromium, arsenic, molybdenum, tin, and cobalt were present in the raw leachate and effluent at concentrations that averaged below 100 µg/l, the treatment system provided significant removal of metals as evidenced by their high concentrations in the sludge. Aluminum, iron, and manganese, which were among the metals showing the highest percent reductions, also were present in high concentrations in the sludge. The poor removal of boron also was demonstrated by a relatively low sludge concentration. The toxicity characteristic leaching procedure (TCLP) results showed that manganese, zinc, and boron have the highest concentration in the TCLP extract. Two dioxins/furans also were detected in the sludge, but at very low concentrations.

TABLE 6-3. CONCENTRATIONS OF POLLUTANTS IN BIOLOGICAL TREATMENT SYSTEM EFFLUENT - LEACHATE SUBCATEGORY

Pollutant	Units	Effluent Concentration			Mean %
		Minimum	Maximum	Mean	Removal(1)
BOD$_5$	mg/l	--	--	39	0
COD	mg/l	74	110	92	0
TOC	mg/l	66	69	68	3
TSS	mg/l	14	27	20	0
Ammonia	mg/l	14	14	14	17
TKN	mg/l	15.8	17	16	6
Oil & Grease	mg/l	1.9	9.5	5.7	0
Aluminum	µg/l	300	490	395	34
Iron	µg/l	3,900	5,400	4,650	69
Manganese	µg/l	400	590	495	44
Boron	µg/l	220	250	235	0
Lead	µg/l	<50	<50	<50	(2)
Vanadium	µg/l	23	36	30	0
Barium	µg/l	43	49	46	33
Cadmium	µg/l	<5	<5	<5	(2)
Molybdenum	µg/l	<10	<10	<10	29
Cobalt	µg/l	4	7.2	5.6	60
Chromium	µg/l	49	100	74	29
Copper	µg/l	37	96	66	0
Nickel	µg/l	41	45	43	0
Titanium	µg/l	23	26	24	0
Zinc	µg/l	31	43	37	0
Arsenic	µg/l	15	21	18	33
Antimony	µg/l	<10	<10	<10	(2)
Mercury	µg/l	0.6	0.8	0.7	0
Tin	µg/l	<13	<13	<13	(2)
Bis(2-Chloroethyl) Ether	µg/l	<10	<10	<10	17
Thioxanthone	µg/l	<10	<10	<10	80

NOTES:

(1) Mean % removal was calculated using the EPA-ITD sampling data from the landfill with biological treatment of leachate. The formula used to calculate the % removal was:

$$\text{Mean \% Removal} = \frac{\sum_{i}^{n} \left(\frac{\text{mean influent} - \text{mean effluent}}{\text{mean influent}}\right) \times 100}{n}$$

TABLE 6-3. CONCENTRATIONS OF POLLUTANTS IN BIOLOGICAL TREATMENT SYSTEM EFFLUENT - LEACHATE SUBCATEGORY (Continued)

NOTES: (Continued)

Mean influent refers to the influent to the biological treatment systems, mean effluent is the clarified plant effluent. This sampling data is contained in Appendix A (Site C).

n = 1, the number of landfills with biological treatment on the EPA-ITD sampling program.

For those pollutants where effluent concentrations were reported less than the detection limit (for example, thioxanthone, <10 μg/l), the detection limit (10 μg/l) was used in the calculation.

(2) % removal has not been reported for these pollutants since both influent and effluent concentrations are below the detection limit.

TABLE 6-4. CONCENTRATIONS OF POLLUTANTS IN BIOLOGICAL TREATMENT SYSTEM SLUDGE - LEACHATE SUBCATEGORY(1)

	Sludge Sample		Results of TCLP
Pollutant	(mg/kg)(2)	(ppt)	(µg/l)(3)
Aluminum	17,600	--	607
Iron	206,000	--	623
Manganese	1,520	--	4,400
Boron	450	--	1,330
Lead	909	--	<200
Copper	3,790	--	235
Chromium	4,150	--	88
Arsenic	864	--	<20
Molybdenum	450	--	<100
Tin	460	--	106
Cobalt	227	--	107
Vanadium	400	--	<50
Barium	450	--	598
Cadmium	73	--	<10
Nickel	181	--	164
Titanium	350	--	<50
Zinc	481	--	1,660
Antimony	114	--	<20
Mercury	3.60	--	<0.2
Total HpCDF	--	0.07	--
OCDF	--	0.31	--

NOTES:

(1) The biological treatment system sampled was an activated sludge plant. The sludge sample was dewatered sludge from the activated sludge system.

(2) mg/kg reported on a wet basis.

(3) TCLP = toxicity characteristic leaching procedure.

6.1.5 Advanced Treatment

6.1.5.1 Treated Effluent Data

Two facilities sampled during the EPA-ITD study provided advanced treatment for landfill leachate. One facility used biological treatment and clarification followed by filtration, air stripping, and two-stage carbon adsorption. Discharge was to a POTW. The other facility used aerated equalization, lime precipitation and clarification, ammonia stripping, activated sludge biological treatment, clarification, sand filtration, and chlorination prior to direct discharge to surface waters.

Conventional and Nonconventional Pollutants

Table 6-5 summarizes effluent data for selected pollutants. The advanced treatment systems provided 54 to 78 percent removal of BOD_5, COD, and TOC. Effluent BOD_5 concentrations averaged 8.2 mg/l, typical of advanced wastewater treatment system performance. Ammonia and TKN also showed significant reductions (90 to 92 percent), averaging 14 mg/l in the effluent.

Metals

Aluminum, iron, manganese, and boron were the only metals found in raw leachate at concentrations higher than 1,000 μg/l. Average reductions of these metals ranged from 36 to over 90 percent; however, the effluent concentrations of boron and iron averaged over 1,000 μg/l. Effluent concentrations of other toxic metals (i.e., cadmium, chromium, copper, lead, nickel, arsenic, etc.) were below 100 μg/l.

Organic Pollutants

Six toxic organic compounds and one pesticide were detected in the effluents after advanced treatment as shown in Table 6-5. None of the organics found in the effluents were detected in the raw leachate. Seven different organic pollutants found in the raw leachate were below their detection limits in the effluent. This apparent anomaly may be due to the detention time of the treatment systems. Consequently, no conclusions regarding the effectiveness of advanced treatment systems for removal of toxic organics can be made from the limited sampling data.

In summary, the advanced treatment systems provide significantly higher reductions of conventional and nonconventional pollutants and metals as compared to preliminary or solely biological treatment systems. Long-term sampling is needed to

TABLE 6-5. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM EFFLUENTS - LEACHATE SUBCATEGORY(2)

Pollutant	Effluent Concentration(1)			Mean %
	Minimum	Maximum	Mean	Removal(3)
BOD5, mg/l	1	17	8	78
COD, mg/l	176	464	271	54
TOC, mg/l	52	87	72	63
TSS, mg/l	1582	3280	2289	33
Ammonia, mg/l	5.2	19	14	92
TKN, mg/l	9.8	19	14	90
Oil & Grease, mg/l	<1	1.3	1.1	2
Aluminum	94	220	144	47
Iron	310	2,820	1,408	92
Manganese	53	1,070	599	79
Boron	4,700	7,100	5,505	32
Zinc	20	300	155	0
Barium	74	708	473	32
Nickel	<12	88	64	45
Arsenic	6.2	7.6	7.1	47
Copper	5.6	16	9.5	32
Chromium	7	15	11	66
Lead	<50	<50	<50	(4)
Vanadium	<2	6	3	78
Cadmium	<5	<5	<5	(4)
Molybdenum	<10	<10	<10	(4)
Tin	<13	<13	<13	(4)
Cobalt	4.5	15	8.3	55
Antimony	<10	<10	<10	(4)
Titanium	12	50	25	30
Mercury	<0.2	<0.2	<0.2	(4)
Benzidene	<50	198	87	0
Bis(2-Chloroethoxy)Methane	<10	114	36	0
Dibenzofuran	<10	203	58	0
Dimethyl Phthalate	<10	39	17	0
N-Dodecane (N-C12)	<10	85	42	0
N-Octacosane (N-C28)	<10	51	20	0
TEPP	194e	223e	208e	39
MCPP	<5	<5	<5	9
Toluene	<10	<10	<10	13
Chloro-3-Methylphenol, 4-	<10	<10	<10	8
Thioxanthone	<10	<10	<10	46
Acetone	<50	<50	<50	23
Alpha-Terpineol	<10	<10	<10	19
Isophorone	<10	<10	<10	16
N-Tetracosane (N-C24)	<10	<10	<10	44
Vinyl Acetate	<10	<10	<10	13
Dibenzothiophene	<10	92	30	0

TABLE 6-5. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM EFFLUENTS - LEACHATE SUBCATEGORY(2) (Continued)

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e = estimated value

NOTES:

(1) All concentrations expressed in µg/l, unless otherwise noted.

(2) Data presented in this table reflects the two landfills in the EPA-ITD sampling data base with advanced treatment. These landfills are Site A, which has biological treatment, clarification, filtration, air stripping, and carbon adsorption; and Site B, which has equalization, lime precipitation and clarification, ammonia stripping, activated sludge, clarification, filtration and chlorination.

(3) Mean % removal was calculated using EPA ITD sampling data from landfills with advanced leachate treatment systems. The formula used to calculate the % removal was:

$$\text{Mean \% Removal} = \frac{\sum_{i}^{n} \frac{(\text{mean influent} - \text{mean effluent})}{\text{mean influent}} \times 100}{n}$$

Where mean influent and mean effluent concentrations were calculated for each landfill with advanced treatment (Sites A and B) using the data in Appendix A. Influent reflects raw leachate quality and effluent is final treatment plant effluent sampled downstream of all treatment units.

n = 2, the number of landfills in the EPA-ITD sampling data base with advanced treatment.

For those pollutants where effluent concentrations were reported less than the detection limit (for example, toluene, <10 µg/l), the detection limit was used in the calculation (10 µg/l).

(4) Mean % removal is not reported for those pollutants where both influent and effluent concentrations were below the detection limit.

evaluate the effectiveness of the advanced systems for removal of specific toxic organic pollutants from leachates.

6.1.5.2 Residuals Data

Selected metals and toxic organics found in the advanced treatment system sludges are summarized in Table 6-6. Iron, aluminum, and manganese, found in the raw leachate in high concentrations and significantly reduced by advanced treatment, also were found in high concentrations in the sludge. On the other hand, chromium and vanadium were not present in high concentrations in the raw leachate; however, the advanced treatment system was highly effective in removing these metals and concentrating them in the sludge. The TCLP results showed that manganese, boron, and barium have the highest concentrations in the TCLP extract. Relative to its sludge concentration, molybdenum was readily leached from the sludge in the TCLP test.

Approximately 50 percent of the organics detected in the sludges were not found in either the raw leachates or the treated effluent. Again, this may be partially due to detention times in the treatment system in addition to sludge age and sludge wasting rates. Only one sludge sample was analyzed for dioxins/furans. The isomer, OCDD, was detected at a concentration of 101 ppt.

6.1.6 Other Control and Treatment Technologies

In addition to treatment and discharge, the HWT industry manages leachate by recirculation, solidification and reburial, deep well injection, and contract hauling to aqueous hazardous waste treaters. Recirculation involves spraying collected leachate back onto open landfill cells to enhance evaporation of the leachate. This practice is not limited to arid areas of the United States. Solidification and reburial is practiced when leachate volumes are relatively small. Raw leachate is mixed with lime or other chemical fixation materials to a consistency that passes the Resource Conservation and Recovery Act (RCRA) test for a solid (i.e., no free liquid) and reburied in the landfill. Deep well injection also is used by facilities with small volumes of leachate. This practice is limited to areas where injection wells are common, such as Texas and Louisiana. Hauling of leachate to an aqueous hazardous waste treater is a common, yet expensive option. In some cases, this practice is used as the last resort after a POTW rejects the leachate; in other cases, landfill owners prefer sending the leachate to a commercial aqueous treater for liability reasons.

TABLE 6-6. CONCENTRATIONS OF SELECTED POLLUTANTS IN ADVANCED TREATMENT SYSTEM SLUDGES - LEACHATE SUBCATEGORY

		Sludge Sample			Results of TCLP (µg/l)(3)		
Pollutant	Units(2)	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Aluminum	mg/kg	2,080	4,880	3,480	<200	<200	<200
Iron	mg/kg	1,910	396,000	199,000	--	--	250
Manganese	mg/kg	48	35,600	17,800	<15	12,500	6,260
Boron	mg/kg	113	1,930	1,020	666	4,860	2,760
Zinc	mg/kg	13	1,380	696	46	730	388
Barium	mg/kg	<17	7,880	3,950	--	--	4,240
Arsenic	mg/kg	<4	407	206	<20	<20	<20
Molybdenum	mg/kg	39	105	72	--	--	223
Nickel	mg/kg	6	102	54	--	--	57
Antimony	mg/kg	--	--	<4	--	--	51
Vanadium	mg/kg	<9	141	75	<50	<50	<50
Titanium	mg/kg	85	200	142	<50	<50	<50
Cadmium	mg/kg	20	35	28	<10	<10	<10
Chromium	mg/kg	18	124	71	--	--	80
Cobalt	mg/kg	<10	64	37	<50	<50	<50
Copper	mg/kg	<5	127	66	<25	<25	<25
Lead	mg/kg	--	--	225	<200	<200	<200
Tin	mg/kg	<17	84	50	<100	<100	<100
Mercury	mg/kg	--	--	<0.2	<0.2	<0.2	<0.2
Acetone	µg/l	<50	72	61	--	--	--
Benzidine	µg/l	<50	252	151	--	--	--
Ethylbenzene	µg/l	<10	12	11	--	--	--
Isophorone	µg/l	<10	390	200	--	--	--
N-Octacosane (N-C28)	µg/l	<10	81	46	--	--	--
N-Eicosane (N-C20)	µg/l	<22	2,807	1,415	--	--	101
N-Hexacosane (N-C26)	µg/l	<22	5,645	2,834	--	--	142
N-Tetracosane (N-C24)	µg/l	<10	--	<22	--	--	156
Toluene	µg/l	<10	39	24	--	--	--
Butanone, 2- (MEK)	µg/l	<50	2,070	1,060	--	--	--
Isobutyl Alcohol	µg/l	<10	12	11	--	--	--
Bis(2-Ethylhexyl) Phthalate	µg/l	<22	2,704	1,363	--	--	<10
OCDD	ppt	--	--	101	--	--	--

NOTES:

(1) Data presented is from sludge analyses of landfills with advanced treatment (Sites A and B) in the EPA-ITD sampling data base. The Site A sludge sample (treatment consists of biological treatment, clarification, filtration, air stripping, neutralization, and carbon adsorption) was collected from the bottom of the clarifier. The Site B sludge sample (treatment consists of equalization, flocculation, clarification, ammonia stripping, activated sludge, filtration and chlorination) was taken from the filter press which dewaters both clarifier bottoms and wasted sludge from the activated sludge unit.

(2) Metals concentrations in mg/kg reported on a wet sludge basis, organics in µg/l, and dioxins/furans in ppt, as indicated.

(3) All TCLP concentrations are in µg/l. TCLP = toxicity characteristic leaching procedure.

-- Not tested.

6.1.7 Summary

A wide range of leachate treatment technologies are employed, depending on the requirements of the receiving POTW or NPDES permit. In addition to treatment and discharge, the HWT industry manages leachate by recirculation, solidification and reburial, deep well injection, and contract hauling to aqueous hazardous waste treaters.

Advanced leachate treatment systems that involve biological treatment and physical/chemical effluent polishing processes are capable of achieving up to 90 percent removal of BOD5, COD, TOC, ammonia, and TKN. These systems have achieved effluent BOD5 concentrations of 10 mg/l or less. Even with advanced treatment systems, iron and boron effluent concentrations average over 1,000 µg/l. Raw leachate concentrations of other toxic metals are usually below 500 µg/l and frequently less than 100 µg/l. Some metals removal occurs during the biological treatment process, as evidenced by the concentrations of metals in the sludges. The metals with the highest concentrations in the sludges are those with high concentrations in the raw leachate (i.e., iron, manganese, aluminum). Boron, whose concentrations are frequently high in raw leachate, demonstrates relatively poor removal with high effluent concentrations and relatively low sludge concentrations.

Several organic compounds were detected in the effluents from the advanced systems. With the exception of one pesticide, the concentrations averaged less than 100 µg/l. More organic compounds were detected in the sludge from the biological process, including 2-butanone, whose concentration averaged over 1,000 µg/l. Whether or not difficulties with the analytical methods have any effect on the organics data for treated leachate cannot be determined because there are no data from other studies for comparison.

6.2 SCRUBBER WASTEWATER TREATMENT

Scrubber wastewater treatment systems are either chemical precipitation/sedimentation processes or chemical precipitation/sedimentation with filtration and activated carbon. Chemical precipitation/sedimentation systems are used to treat recirculating scrubber wastes and scrubber blowdown. When regulatory agencies impose more stringent limits on the blowdown discharge, the blowdown portion of the scrubber wastewaters is treated further with filtration and activated carbon.

6.2.1 Sources of Data

All data regarding treatment technologies and effluent data were obtained from the EPA-ITD study sampling and presampling efforts. Telephone contacts supplied information on other scrubber wastewater management practices.

6.2.2 TSCA versus RCRA Facilities

Both Toxic Substances Control Act (TSCA) and permitted RCRA incineration facilities are required to control the stack emissions of hydrogen chloride gases. This requires wet scrubbers. Consequently, both TSCA and RCRA incinerators generate scrubber wastewater. The chloride content of PCB-burning TSCA scrubber wastewaters is normally higher because of the larger amounts of chlorinated wastes burned compared to RCRA facilities. No differences between TSCA and RCRA facilities were found in the technologies employed for scrubber wastewater treatment prior to discharge. If additional treatment of the blowdown stream occurred, it was in response to state or local permit conditions. For example, a TSCA facility in Region V discharging to a POTW used filtration and activated carbon to polish their effluent, while a TSCA facility in Region VI discharged the blowdown from a chemical precipitation/sedimentation system directly to surface waters without further treatment.

6.2.3 Physical/Chemical Treatment

Two incineration facilities sampled during the EPA-ITD study provided only chemical precipitation/sedimentation prior to discharge. One facility was a TSCA incinerator, and both facilities discharged directly to surface waters.

6.2.3.1 Treated Effluent Data

Conventional and Nonconventional Pollutants

The precipitation/sedimentation treatment systems provided no significant reduction of COD or TOC; however, the TOC data indicated a relatively low concentration of TOC in the scrubber wastewaters, as shown in Table 6-7. Only minimal reduction in TSS was achieved, but the effluent concentrations averaged 51 mg/l. Both high TDS and chloride concentrations were present in the effluents as a result of the removal of hydrogen chloride gases by the scrubbers. Effluent fluoride concentrations averaged 10.3 mg/l.

Metals

Aluminum, iron, boron, and zinc were found in concentrations higher than 1,000 μg/l in the treatment system effluents. Mean

TABLE 6-7. CONCENTRATIONS OF POLLUTANTS IN PHYSICAL/CHEMICAL TREATMENT SYSTEM EFFLUENTS - SCRUBBER WASTEWATER SUBCATEGORY(1)

Pollutant	Units	Effluent Concentration Minimum	Effluent Concentration Maximum	Effluent Concentration Mean	Mean % Removal(2)
COD	mg/l	129	840	423	0
TOC	mg/l	14	60	45	10
TSS	mg/l	32	100	51	13
TDS	mg/l	4,060	11,100	7,820	0
Chloride	mg/l	2,300	9,000	5,550	2
Fluoride	mg/l	0.65	15	10.3	38
Ammonia	mg/l	<0.1	<0.1	<0.1	(3)
TKN	mg/l	1.3	5.9	3.2	14
Calcium	mg/l	490	3,790	2,110	0
Magnesium	mg/l	4.8	390	182	4
Aluminum	µg/l	780	1,130	1,020	78
Iron	µg/l	383	1,900	1,030	76
Zinc	µg/l	200	1,490	676	43
Boron	µg/l	220	1,550	710	18
Copper	µg/l	34	794	288	61
Manganese	µg/l	118	400	240	26
Tin	µg/l	<13	<13	<13	92
Lead	µg/l	72	383	180	50
Barium	µg/l	180	485	280	10
Cadmium	µg/l	6	25	16	25
Molybdenum	µg/l	130	360	195	13
Vanadium	µg/l	2	17	9	43
Cobalt	µg/l	<4	6.2	4.8	40
Chromium	µg/l	13	21	16	81
Nickel	µg/l	58	81	69	56
Titanium	µg/l	11	67	38	74
Arsenic	µg/l	5	37	21	27
Antimony	µg/l	28	58	39	10
Mercury	µg/l	0.2	0.4	0.3	44
Acetone	µg/l	<50	90	60	6
Benzene	µg/l	<10	59	22	2
Benzo(b)fluoranthene	µg/l	<10	12	10	0
Thioxanthone	µg/l	<10	366	99	0
Bromoform	µg/l	<10	38	17	0
Heptachlor Epoxide	µg/l	<0.2	1.3	0.8	0

TABLE 6-7. CONCENTRATIONS OF POLLUTANTS IN PHYSICAL/CHEMICAL TREATMENT SYSTEM EFFLUENTS - SCRUBBER WASTEWATER SUBCATEGORY(1) (Continued)

NOTES:

(1) Data presented are the results of the EPA-ITD sampling program of the Scrubber subcategory with physical/chemical treatment systems (Sites H and J).

(2) Mean % removal was calculated using the EPA-ITD sampling data for the two scrubbers with physical/chemical treatment (Sites H and J) using the following formula:

$$\text{Mean \% Removal} = \frac{\displaystyle\sum_{i}^{n} \frac{(\text{mean influent} - \text{mean effluent})}{\text{mean influent}} \times 100}{n}$$

Where mean influent and mean effluent concentrations were calculated for each of the scrubbers (Sites H and J) using the data in Appendix B. Influent refers to raw scrubber wastewater and effluent to the facilities final, treated wastewater.

n = 2, the number of scrubbers with physical/ chemical treatment in the EPA-ITD sampling data base.

For those pollutants where effluent concentrations were reported less than the detection limit (for example, tin, <13 μg/l) the detection limit (13 μg/l) was used in the calculation.

(3) Mean % removal is not reported for pollutants where both influent and effluent concentrations were below the detection limit.

reductions of these metals ranged from 18 to 78 percent, with boron showing the lowest average percent removal and aluminum the highest. Arsenic, cadmium, lead, tin, titanium, nickel, chromium, antimony, and vanadium were found at effluent concentrations below 100 µg/l. The treatment systems provided significant removals of some of these metals.

Organic Pollutants

Five toxic organic pollutants and one pesticide were detected in the treated effluent, but at relatively low concentrations. The presence of only a few organics at low concentrations is expected in scrubber wastewaters from properly operated incinerators. The organics present may have been contaminants in the surface and well waters that supply the scrubbers with make-up water.

6.2.3.2 Residuals Data

Selected metals, toxic organics, and dioxins/furans found in the physical/chemical treatment system sludges are summarized in Table 6-8. Thirteen metals were found at concentrations above 1,000 mg/kg in the sludges, including metals whose effluent concentrations were below 100 µg/l (i.e., lead, tin, nickel, titanium, chromium, and vanadium). Copper, which averaged 288 µg/l in the effluent, was highly concentrated in the sludges. The TCLP extracts showed little leaching potential for most metals except boron, zinc, and barium.

Two toxic organics, acetone and bromoform, were detected in the sludges. The concentration of acetone was relatively high. Although not detected in the compositional analysis, three additional organics were found in the TLCP extracts, but at relatively low concentrations.

The most significant finding in the sludge analyses was the presence of a large number of dioxin/furan isomers, some at high concentrations. Neither the raw scrubber wastewaters nor the treated effluents were tested for these pollutants, so the effectiveness of physical/chemical treatment systems in the removal of dioxins/furans is unknown. The presence of at least 10 isomers in the sludges at concentrations in the ppb range indicates the need for more extensive analyses, including analyses of the treated effluents for dioxins/furans.

6.2.4 Advanced Treatment

Only one incineration facility sampled provided advanced treatment of their scrubber wastewater prior to discharge. A second facility, which was visited but not sampled, also provided advanced treatment. Both advanced treatment systems followed

TABLE 6-8. CONCENTRATIONS OF POLLUTANTS IN PHYSICAL/CHEMICAL TREATMENT SYSTEM SLUDGES - SCRUBBER WASTEWATER SUBCATEGORY(1)

		Sludge Sample			Results of TCLP (ug/l)(3)		
Pollutant	Units(2)	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Aluminum	mg/kg	20,600	289,000	154,800	659	852	756
Iron	mg/kg	11,500	228,000	120,000	<100	108	104
Manganese	mg/kg	575	14,200	7,390	182	189	186
Boron	mg/kg	4,740	7,990	6,360	1,510	2,180	1,840
Zinc	mg/kg	732	97,800	49,300	--	1,400	--
Lead	mg/kg	239	74,200	37,200	--	--	275
Tin	mg/kg	217	21,200	10,700	169	193	181
Copper	mg/kg	116	92,500	46,300	26	127	76
Titanium	mg/kg	359	9,890	5,120	--	--	<50
Nickel	mg/kg	86	18,200	9,140	<40	67	54
Chromium	mg/kg	64	5,530	2,800	--	--	<50
Barium	mg/kg	92	3,370	1,730	1,270	1,420	1,340
Vanadium	mg/kg	22	2,260	1,140	--	--	<50
Antimony	mg/kg	--	--	21	--	--	21
Arsenic	mg/kg	--	--	25	--	--	<20
Cadmium	mg/kg	19	978	499	<10	54	32
Cobalt	mg/kg	--	--	345	--	--	<50
Molybdenum	mg/kg	96	1,300	698	226	491	358
Mercury	mg/kg	--	--	0.88	<0.2	0.2	0.2
Acetone	µg/l	<50	1,496	773	--	--	145
Bromoform	µg/l	<10	32	21	--	--	30
Chloroform	µg/l	--	--	<10	--	--	15
Methylene Chloride	µg/l	--	--	<10	--	--	80
Isobutyl Alcohol	µg/l	--	--	<10	--	--	11
1,2,3,4,6,7,8-HpCDD	ppt	<3.79	31.1	17.5			
Total HpCDD	ppt	<3.79	67.0	35.4			
OCDD	ppt	4.69	155	79.7			
1,2,3,7,8-PCDF	ppt	42.8	838	441			
2,3,4,7,8-PCDF	ppt	84.6	4,296	2,177			
Total PCDF	ppt	117	16,000	8,058			
1,2,3,4,7,8-HxCDF	ppt	22.6	1,596	809			
2,3,4,6,7,8-HxCDF	ppt	155	1,178	666			
1,2,3,6,7,8-HxCDF	ppt	<0.95	353	177			
Total HxCDF	ppt	187	6,966	3,576			
1,2,3,4,6,7,8-HpCDF	ppt	88.2	773	431			
1,2,3,4,7,8,9-HpCDF	ppt	<3.38	59.8	31.6			
Total HpCDF	ppt	261	1,354	808			
OCDF	ppt	559	2,966	1,762			
2,3,7,8-TCDF	ppt	61.2	3,785	1,923			

NOTES:

(1) Data presented are based on sludge analyses from the two incinerator scrubbers with physical/ chemical treatment in the EPA-ITD sampling data base. The scrubber wastewater treatment systems at both of these facilities (Sites H and I) consists of neutralization, clarification and cooling lagoons. Sludge samples were taken from the clarifiers.

(2) Metals concentrations in mg/kg (wet basis), organics in µg/l, TCLP in µg/l and dioxins/furans in ppt.

(3) TCLP = toxicity characteristic leaching procedure.

chemical precipitation/sedimentation with filtration and carbon adsorption.

6.2.4.1 Treated Effluent Data

Conventional and Nonconventional Pollutants

TSS reduction averaged over 99 percent and TOC reduction averaged 89 percent by the advanced treatment system. However, the percent reductions are misleading because this facility recirculated its scrubber water with a high TSS load and treated only the blowdown stream. Effluent TSS and TOC concentrations averaged 88 and 45 mg/l, respectively (Table 6-9) which is comparable to physical/chemical system effluents (Table 6-7). The effluent fluoride concentrations were also similar for the two types of treatment systems. Because the sampled facility recirculated high TSS concentrations in its scrubber water and only treated the blowdown, ammonia was added to the scrubber water to neutralize the acid gases. As a result of this operational procedure, high ammonia and TKN concentrations were found in the treated effluent. Although the treatment system achieved a 50 percent reduction in the ammonia, its effluent concentrations averaged 1,070 mg/l.

Metals

Sixteen metals were found in the raw scrubber wastewater at concentrations higher than 1,000 μg/l. Recirculation of the scrubber water and treatment of only the blowdown stream is the reason for the high metals concentrations compared to the raw scrubber water discussed in Section 6.2.3. Of these 16 metals, aluminum, lead, chromium, copper, iron, titanium, zinc, tin, and arsenic had removals of 99 percent or greater with the advanced treatment system. Greater than 99 percent removal of mercury also was achieved with an effluent concentration of <0.2 μg/l. The percent removals of vanadium, barium, molybdenum, cobalt, and antimony were 90 percent or greater. Even with high percent removals, the effluent concentrations of iron, manganese, boron, and zinc were above 1,000 μg/l; however, the effluent concentrations of aluminum, lead, tin, cobalt, chromium, titanium, and arsenic averaged below 100 μg/l.

Organic Pollutants

Six toxic organic pollutants were detected in the treated effluent after carbon adsorption. Only thioxanthone also was found in the raw scrubber wastewater. Three other organic compounds found in the raw scrubber water were treated to below detection level concentrations.

TABLE 6-9. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM EFFLUENTS - SCRUBBER WASTEWATER SUBCATEGORY

Pollutant	Effluent Concentration(1) Minimum	Maximum	Mean	Mean % Removal(3)
COD, mg/l	310	380	345	25
TOC, mg/l	16	74	45	89
TSS, mg/l	17	160	88	99
TDS, mg/l	9,700	9,800	9,750	0
Chloride, mg/l	--	--	4,000	0
Fluoride, mg/l	12	15	14	94
Ammonia-N(4), mg/l	820	1,320	1,070	51
TKN(4), mg/l	80	270	175	0
Calcium. mg/l	180	410	295	75
Magnesium, mg/l	100	130	115	79
Iron	1,100	1,100	1,100	99
Manganese	1,600	1,800	1,700	82
Boron	7,100	12,000	9,550	28
Molybdenum	650	1,200	925	91
Nickel	470	600	535	89
Zinc	570	3,000	1,780	99
Antimony	340	545	442	90
Aluminum	13	45	29	99
Lead	<50	<50	<50	99
Vanadium	<2	<2	<2	98
Barium	190	210	200	97
Cadmium	170	210	190	89
Tin	--	--	<65	99
Cobalt	71	86	78	91
Chromium	5	15	10	99
Copper	88	130	109	99
Titanium	<10	<10	<10	99
Arsenic	6	11	8	99
Mercury	<0.2	<0.2	<0.2	99
Butyl Benzyl Phthalate	<10	15	13	0
N-Dodecane (N-C12)	<10	28	19	0
N-Tetradecane (N-C14)	<10	15	13	0
Chloronaphthalene, 2-	<10	48	29	0
Chlorophenol, 2-	<10	10	10	0
Thioxanthone	<10	392	201	90
Fluoranthene	<10	<10	<10	83
N-Nitrosodi-N-Propylamine	<20	<20	<20	98
Pyrene	<10	<10	<10	94

TABLE 6-9. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM EFFLUENTS - SCRUBBER WASTEWATER SUBCATEGORY (Continued)

NOTES:

(1) All concentrations expressed in μg/l, unless otherwise noted.

(2) Data presented are the results of the EPA-ITD sampling effort at incinerators with advanced scrubber wastewater treatment systems (Site G). Site G treatment includes flocculation, clarification, filtration, and carbon adsorption.

(3) Mean % removal was calculated from EPA-ITD sampling data for the incinerator with advanced treatment of scrubber wastewaters using the following formula:

$$\text{Mean \% Removal} = \frac{\sum_{i}^{n} \frac{(\text{mean influent} - \text{mean effluent})}{\text{mean influent}} \times 100}{n}$$

Where mean influent and mean effluent concentrations were obtained from Sites G sampling data contained in Appendix B. Influent samples were raw scrubber wastewater and effluent samples were final treated effluent from the carbon adsorption units.

n = 1, the number of incinerators in the EPA-ITD sampling data base with advanced treatment.

For those pollutants where effluent concentrations were reported less than the detection limit (for example, lead <50 μg/l), the detection limit (50 μg/l) was used in the calculation.

(4) Data reported are the unedited laboratory analytical results. Analytical problems are evident here where ammonia is reported higher than TKN. Possible explanations are discussed in Section 5.1.

In summary, the advanced treatment system provided high removals of many toxic metals. Compared to physical/chemical treatment, the advanced treatment system achieved significantly lower effluent concentrations of aluminum and copper. In general though, operation of the scrubber water system with a low TSS load (i.e., treating the recirculating stream with chemical precipitation/ sedimentation) produced lower metals concentrations in the final effluent. Addition of ammonia for neutralization in the high TSS mode of operation may affect metals removal due to formation of chemical complexes that can lower metals removal efficiencies.

6.2.4.2 Residuals Data

Table 6-10 summarizes concentrations of selected metals, toxic organics, and dioxins/furans in the sludge from the advanced treatment system. Although the advanced system includes additional unit processes, sludge is only generated by the chemical precipitation process. Eight metals were found at concentrations above 1,000 mg/kg in the sludge, including metals whose effluent concentrations were below 100 µg/l (i.e., aluminum, titanium, and lead). Zinc, whose concentration ranged over 1,000 µg/l in the treatment system effluent, was highly concentrated in the sludge. Zinc and aluminum also were found at high concentrations in the TCLP extract. These results are in direct contrast to the zinc and aluminum results for the sludges from the other physical/chemical treatment system and also may be the consequence of ammonia addition. Ammonia forms complexes with metals, which hinder their removal by precipitation. These complexes may release metals more readily than sludges without ammonia.

Only one toxic organic, thioxanthone, was detected in the advanced treatment system sludge. Like the physical/chemical system sludges, the advanced treatment system sludge contained a large number of dioxin/furan isomers at high concentrations. Neither the raw scrubber wastewater nor the treated effluent were tested for dioxins/furans, but their presence in the sludge indicates their presence in the raw wastewater and potential presence in the treated effluent.

6.2.5 Other Treatment and Disposal Methods

Treatment and discharge, either directly or indirectly, are the primary management practices for incinerators with scrubber wastewater. Other means of disposal include landfills, evaporation, and contract hauling. These methods are applicable primarily to systems with small-volume discharges. Those incinerators using contract hauling send scrubber wastewaters to commercial aqueous hazardous waste treaters. Prior to landfilling, scrubber wastewaters are solidified or chemically fixed. Lime and

TABLE 6-10. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM SLUDGE - SCRUBBER WASTEWATER SUBCATEGORY(1)

Pollutant	Units(2)	Sludge Sample	Results of TCLP(3) (µg/l)
Aluminum	mg/kg	20,300	51,200
Iron	mg/kg	170,000	399
Lead	mg/kg	14,300	3,230
Barium	mg/kg	1,460	1,100
Molybdenum	mg/kg	1,[illegible]70	290
Copper	mg/kg	2,910	9,660
Titanium	mg/kg	2,140	<50
Zinc	mg/kg	65,600	642,000
Manganese	mg/kg	818	11,300
Nickel	mg/kg	569	2,110
Boron	mg/kg	661	4,790
Cadmium	mg/kg	184	1,730
Antimony	mg/kg	<145	325
Arsenic	mg/kg	13	48
Chromium	mg/kg	486	49
Cobalt	mg/kg	121	626
Tin	mg/kg	792	1,040
Mercury	mg/kg	17.6	<0.2
2,3,7,8-TCDF	ppt	27.78	--
2,3,7,8-TCCDD	ppt	16.86	--
1,2,3,7,8-PCDF	ppt	20.15	--
2,3,4,7,8-PCDF	ppt	249.85	--
Total PCDF	ppt	694.28	--
1,2,3,7,8-PCDD	ppt	14.69	--
Total PCDD	ppt	223.59	--
1,2,3,4,7,8-HxCDF	ppt	117.08	--
1,2,3,6,7,8-HxCDF	ppt	69.88	--
Total HxCDF	ppt	687.99	--
1,2,3,6,7,8-HxCDD	ppt	26.24	--
Total HxCDD	ppt	351.35	--
1,2,3,4,6,7,8-HpCDF	ppt	310.74	--
1,2,3,4,7,8,9-HpCDF	ppt	49.95	--
Total HpCDF	ppt	581.53	--
1,2,3,4,6,7,8-HpCDD	ppt	133.92	--
Total HpCDD	ppt	297.78	--
OCDF	ppt	3,722.38	--
OCDD	ppt	2,209.40	--

TABLE 6-10. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM SLUDGE - SCRUBBER WASTEWATER SUBCATEGORY(1) (Continued)

NOTES:

(1) Data presented are the results of analyses of the sludge sampled obtained from the one incinerator in the EPA-ITD sampling data base with advanced scrubber wastewater treatment (Site G). Treatment at this facility included flocculation, clarification, filtration, and carbon adsorption. Settled solids were sent from the clarifier to a vacuum sludge filter. The sludge sampled was collected from the vacuum sludge filter discharge.

(2) Metals concentrations in mg/kg, wet bases.

(3) TCLP = toxicity characteristic leaching procedure.

sometimes ash from the incinerator are used for this purpose. Evaporation in surface impoundments is an option in arid climates or in areas where land is inexpensive and readily available. Finally, on-site generators such as industrial facilities may treat the scrubber wastewaters along with their process wastes or comingle the scrubber wastewaters with noncontact cooling water for discharge.

6.2.6 Summary of Scrubber Wastewater Treatment

Scrubber wastewater treatment systems consist of technologies designed for the removal of inorganic pollutants. Chemical precipitation/sedimentation provides metals removal, and filtration and carbon adsorption are used if necessary to polish the effluents to meet permit limits. Consequently, no significant reduction in COD occurred, but effluent concentrations were relatively low. Even with advanced treatment, effluent concentrations of iron, manganese, boron, molybdenum, and zinc were above 1,000 μg/l. Effluent concentrations of the toxic metals were below 100 μg/l.

The most significant result was the presence of a large number of dioxin/furan isomers, some at extremely high concentrations, in the scrubber wastewater treatment system sludges. Dioxins/furans are relatively insoluble in water and tend to adsorb onto particulates. Although the treatment system effluents were not analyzed for dioxins/furans, these compounds may be discharged to POTWs or surface waters by way of the suspended solids in the treated effluents. Further analysis of treated effluents is needed to determine if the treatment technologies in-place are effectively removing dioxins/furans. Other methods of scrubber wastewater disposal, besides the most common treatment and disposal methods, include landfills, evaporation, and contract hauling.

6.3 AQUEOUS HAZARDOUS WASTE TREATMENT

Aqueous hazardous waste treatment systems range from chemical precipitation/sedimentation units designed to treat inorganic industrial wastes to advanced treatment systems that may incorporate biological treatment and tertiary treatment in addition to chemical precipitation. Complex facilities accept a wide variety of wastes for treatment, including leachates and inorganic wastes. Treatment operations may be batch treatment, continuous flow, or both. Some facilities segregate incoming wastes that require specialized pretreatment (e.g., cyanide wastes, chromium wastes), while other facilities use one waste to treat another (e.g., mixing acid wastes with caustic wastes. Some facilities combine all of the wastes prior to any treatment.

6.3.1 Sources of Data

The two sources of data available to this study are the EPA-ITD sampling effort at four aqueous hazardous waste treaters and an Office of Solid Waste (OSW) sampling program at two other facilities. The EPA-ITD study produced two consecutive days of data (24-hour composites), while one of the OSW study facilities was sampled for three consecutive days. Twelve batches were sampled over a 4-day period at the second OSW sampling facility.

The list of analytes for the two studies also differed. At one OSW sampling facility, the analytes were 15 metals, 29 volatile organics, TCLP, and miscellaneous conventional and nonconventional pollutants. At the other OSW sampling facility, the analytes were 35 volatile organics, 58 extractables, seven metals, TCLP, and miscellaneous conventional and nonconventional pollutants. The list of analytes for the EPA-ITD study included 27 metals, the Appendix IX organics, pesticides/herbicides, dioxins/furans, TCLP, and miscellaneous conventional and nonconventional pollutants.

6.3.2 Physical/Chemical Treatment

Three aqueous hazardous waste treaters operated pretreatment, chemical precipitation, and solids removal technologies. The first facility pretreated oily wastes prior to mixing with all other incoming wastes. The combined wastes were treated by a potential four-stage chemical precipitation reactor, flocculating clarifier, and settling tank. The second facility used batch pretreatment (only if necessary), oil-water-solids separation, chemical precipitation, flotation, and coagulation. The third facility employed cyanide oxidation and chromium reduction, using iron-bearing wastes in the chromium reduction process. The pretreated wastes were combined with other wastes for chemical precipitation followed by vacuum filtration for solids removal.

6.3.2.1 Treated Effluent Data

Conventional and Nonconventional Pollutants

Average effluent concentrations and percent removals of conventional and nonconventional pollutants are summarized in Table 6-11. Relatively poor BOD_5, TOC, and COD removals were achieved by treatment technologies designed primarily for the treatment of inorganic wastes. The high effluent BOD_5 and TOC concentrations indicate that although the treatment systems are not designed for removal of organic wastes, the wastes accepted at these facilities contain a significant amount of organics. The treatment systems provided significant TSS reductions (average 92 percent removal).

TABLE 6-11. CONCENTRATIONS OF POLLUTANTS IN PHYSICAL/CHEMICAL TREATMENT SYSTEMS - AQUEOUS TREATERS SUBCATEGORY(2)

Pollutant	Effluent Concentration(1) Minimum	Maximum	Mean	Mean % Removal(3)
BOD5, mg/l	189	930	514	46
COD, mg/l	3,360	11,400	7,180	34
TOC. mg/l	13	17,000	2,070	30
TSS, mg/l	2	458	79	92
O&G, mg/l	34	153	71	88
Ammonia(4), mg/l	10.8	870	436	0
TKN(4), mg/l	60	694	223	8
Phenols, mg/l	0.62	27.5	12.3	18
Cyanide, mg/l	0.24	1.9	1.1	44
Fluoride, mg/l	0.6	370	185	38
Aluminum	31,800	45,000	36,600	6
Iron	4,760	21,000	10,050	86
Boron	16,000	53,000	34,400	6
Nickel	169	1,500	456	53
Zinc	60	6,200	905	93
Manganese	42	760	343	90
Barium	25	120	61	64
Molybdenum	<100	890	687	20
Antimony	31	158	82	82
Cadmium	<5	20	10	88
Chromium	100	566	223	83
Mercury	<.2	<.4	<0.3	85
Copper	32	177	136	93
Lead	<10	110	23	91
Titanium	<10	11	11	77
Acetone	<50	7,706	3,760	75
Alpha-Terpineol	<10	5,223	1,748	40
Benzene	<10	15,407	3,884	31
Benzidine	<50	22,723	7,608	0
Bis (2-Ethylhexyl) Phthalate	<10	4,266	1,429	42
Ethylbenzene	<10	459	65	65
Methylene Chloride	<10	360	46	39
N-Decane (N-C10)	<10	1,717	676	0
N-Dodecane (N-C12)	<10	20,263	6,761	0
Toluene	<10	34,931	2,664	41
Trichloroethene	<10	103	16	26
Trichloroethane, 1,1,1-	<10	759	113	41
Butanone, 2- (MEK)	<50	108,526	30,030	60
Chloro-3-Methyphenol, 4-	2,205	2,443	2,324	6
Benzyl Alcohol	<10	2,669	675	14
Biphenyl	<10	<10	<10	0

TABLE 6-11. CONCENTRATIONS OF POLLUTANTS IN PHYSICAL/CHEMICAL TREATMENT SYSTEMS - AQUEOUS TREATERS SUBCATEGORY(2) (Continued)

	Effluent Concentration(1)			
Pollutant	Minimum	Maximum	Mean	Mean % Removal(3)
Hexanoic Acid	<10	85	48	32
Isobutyl Acid	<10	82	28	29
Thioxanthone	<10	35,060	8,772	0
Tripropyleneglycol Methyl Ether	<10	5,544	1,394	0
Vinyl Acetate	<10	1,230	315	0
Isophorone	<10	354	181	42
Methacrylonitrile	<10	30	15	0
Naphthalene	39	162	119	22
Styrene	<10	917	308	31
Dichloroethane, 1,1-	<10	23	11	29
Dichloroethane, 1,2-	<10	37	12	0
Dibromoethane, 1,2- (EDB)	<10	24	14	0
Diethyl Ether	<50	98	62	0
Di-N-Butyl Phthalate	<10	520	180	26
N-Docosane (N-C22)	<10	<10	<10	40
Chloronaphthalene, 2-	<10	<10	<10	46
Methylnaphthalene, 2-	<10	<10	<10	50
N-Hexadecane (N-C16)	<10	<10	<10	50
Hexanone, 2-	<10	<10	<10	48
Dinitrotoluene, 2,4-	<10	<10	<10	45
Diphenylhydrazine 1,2-	<20	<20	<20	6
Pentachlorophenol	<50	<50	<50	28
Methyl Methacrylate	<10	<10	<10	4
Fluorene	<10	<10	<10	16
Tetrachloroethene	<10	<10	<10	21
Chloroform	<10	<10	<10	16
Trans,1,2-Dichloroethene	<10	<10	<10	3
Trichloroethane, 1,1,2-	<10	<10	<10	8
P-Cresol	<10	393	202	0
N-Nitrosomorpholine	<10	162	48	0
Butyl Benzyl Phthalate	<10	<10	<10	44
Phenol	<10	4,592	1,561	56
Nitrophenol, 2-	655	1,693	1,174	0
Benzoic Acid	<50	518	284	0
N-Nitrosodi-N-Butylamine	<10	<10	<10	45

TABLE 6-11. CONCENTRATIONS OF POLLUTANTS IN PHYSICAL/CHEMICAL TREATMENT SYSTEMS - AQUEOUS TREATERS SUBCATEGORY(1) (Continued)

NOTES:

(1) All concentrations expressed in μg/l, unless otherwise noted.

(2) Information in this table is based on the sampling results from three aqueous hazardous waste treaters with physical/chemical treatment systems: Site J and L from the EPA-ITD sampling effort and one site from the OSW sampling program. All raw data from these sampling programs are contained in Appendix C.

(3) Mean % removal was calculated based on sampling data from aqueous treaters with physical/chemical treatment systems using the following formula:

$$\text{Mean \% Removal} = \frac{\sum_{i}^{n} \frac{(\text{mean influent} - \text{mean effluent})}{\text{mean influent}} \times 100}{n}$$

Where mean influent is the raw waste water concentration calculated individually for each site. Mean effluent is the final treated site effluent.

n = 3, the number of aqueous hazardous waste treaters in the data base with physical/chemical treatment.

For those pollutants where effluent concentrations were reported less than the detection limit (for example, biphenyl, <10 μg/l), the detection limit (10 μg/l) was used in the calculation.

(4) Data presented are the unedited laboratory analytical results. Evidence of analytical problems can be seen here where ammonia is reported higher than TKN. Possible explanations are discussed in Section 5.1.

The effluent TSS concentration averaged 79 mg/l, which is adequate for facilities discharging to a POTW. High effluent oil and grease concentrations were found as a result of the oily wastes accepted at aqueous hazardous waste treaters. The chemical precipitation/sedimentation systems provided little reduction of ammonia, TKN, and phenol, which is typical of this technology. It is concluded, therefore, that these facilities accept wastes containing high concentrations of conventional and nonconventional pollutants that are not treatable by the technologies in-place.

Metals

Aluminum, iron, boron, nickel, and zinc were found in concentrations higher than 1,000 µg/l in the treated effluent. Average reductions of these metals ranged from 6 percent for boron to 93 percent for zinc. High percent removals were observed for several heavy metals, including cadmium, copper, and lead. The effluent concentrations of these metals were low as a result of low concentrations in the raw waste and a high degree of reduction in the treatment system.

Organic Pollutants

Sixteen toxic organic compounds were detected in the treatment effluent at concentrations above 1,000 µg/l. Because the physical/chemical treatment technologies in-place are not designed for organics removal, the average percent removals were low, ranging from 0 to 75 percent. The highest percent removals were achieved for volatile compounds(acetone, ethylbenzene, 2-butanone), which suggests that volatilization may have been one of the removal mechanisms.

Fifteen compounds averaged zero percent reduction. Included among these were compounds with raw waste concentrations below detection limits but with higher effluent concentrations. Such instances may be attributed to the detention times in the treatment systems as well as the analytical difficulties discussed in Section 5. These factors make it difficult to estimate with accuracy the removals of these and other compounds.

6.3.2.2 Residuals Data

Table 6-12 lists the metals, toxic organics, and dioxins/furans that were found to be concentrated in the chemical sludges from the physical/chemical treatment systems. Aluminum, iron, nickel, chromium, zinc, and lead were found at concentrations above 1,000 mg/kg in the sludges. Aluminum, iron, boron, and zinc were found at high concentrations in the TCLP extracts; however, the TCLP data are from a single sludge sample. Twenty-eight toxic

TABLE 6-12. CONCENTRATIONS OF POLLUTANTS IN PHYSICAL/CHEMICAL TREATMENT SYSTEM SLUDGES - AQUEOUS TREATERS SUBCATEGORY(1)

		Sludge Sample			Results of TCLP (µg/l)		
Pollutant	Units(2)	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Aluminum	mg/kg	1,690	15,100	8,395	--	--	126,000
Iron	mg/kg	2,450	21,300	11,875	--	--	786,000
Nickel	mg/kg	274	2,564	1,532	--	--	1,010
Chromium (total)	mg/kg	344	6,509	2,404	--	--	1,249
Boron	mg/kg	54	362	208	--	--	38,600
Zinc	mg/kg	443	1,890	974	--	--	26,600
Lead	mg/kg	63	2,680	1,089	--	--	896
Copper	mg/kg	158	478	336	--	--	<25
Manganese	mg/kg	19	313	166	--	--	871
Barium	mg/kg	33	1,300	455	--	--	423
Molybdenum	mg/kg	18	24	21	--	--	337
Antimony	mg/kg	18	30	24	--	--	<200
Cadmium	mg/kg	10	66	35	--	--	33
Yttrium	mg/kg	<8	84	46	--	--	149
Mercury	mg/kg	<0.2	101	51	--	--	<0.2
Titanium	mg/kg	<13	472	243	--	--	<50
Silver	mg/kg	0.30	12	6.15	--	--	20
Arsenic	mg/kg	27	45	36.0	--	--	200
Beryllium	mg/kg	<1	2.0	1.5	--	--	5
Calcium	mg/kg	2,040	61,100	31,570	--	--	340,000
Cobalt	mg/kg	12	22	17	--	--	60
Magnesium	mg/kg	303	2,650	1,476	--	--	46,700
Sodium	mg/kg	1,290	14,200	7,745	--	--	2,540,000
Selenium	mg/kg	<0.8	5.0	2.9	--	--	20
Tin	mg/kg	34	47	40	--	--	100
Titanium	mg/kg	<1.6	5.0	3.3	--	--	20
Vanadium	mg/kg	12	27	19	--	--	50
Acetone	µg/l	<50	8,411	1,033	--	--	12,481
Alpha-Terpineol	µg/l	--	--	19,260	--	--	<10
Benzene	µg/l	<2.8	289	38	105	333	219
Chlorobenzene	µg/l	<5.1	12	6.0	--	--	--
Chloroform	µg/l	<2.8	9.9	5.3	--	--	120
Di-N-Butyl Phthalate	µg/l	--	--	12,436	--	--	26
Ethylbenzene	µg/l	<3.2	470	116	--	--	180
Fluorene	µg/l	--	--	1,835	--	--	<10
Methylene Chloride	µg/l	<7.1	304	41	--	--	1,915
N-Docosane (N-C22)	µg/l	--	--	10,107	--	--	<10
N-Hexadecane (N-C16)	µg/l	--	--	9,236	--	--	<10
N-Octadecane (N-C18)	µg/l	--	--	12,908	--	--	<10
N-Triacontane (N-C30)	µg/l	--	--	13,100	--	--	<10
N-Nitrosodiphenylamine	µg/l	--	--	3,675	--	--	<20
Naphthalene	µg/l	165	13,811	6,988	--	--	<10
Trans-1,2-Dichloroethene	µg/l	<2.8	8.9	4.9	--	--	30
Trichloroethene	µg/l	<2.8	540	63	--	--	67
Chloronaphthalene, 2-	µg/l	--	--	21,616	--	--	<10
Dichlorophenol, 2,4-	µg/l	--	--	--	<10	29	20
Dinitrotoluene, 2,4-	µg/l	--	--	1,440	--	--	<10
Chloro-3-Methylphenol, 4-	µg/l	--	--	4,477	<10	107	58
Methylnaphthalene, 2-	µg/l	--	--	20,835	--	--	<10
Isophorone	µg/l	--	--	--	--	--	25

TABLE 6-12. CONCENTRATIONS OF POLLUTANTS IN PHYSICAL/CHEMICAL TREATMENT SYSTEM SLUDGES - AQUEOUS TREATERS SUBCATEGORY(1) (Continued)

		Sludge Sample			Results of TCLP (µg/l)		
Pollutant	Units(2)	Minimum	Maximum	Mean	Minimum	Maximum	Mean
P-Cymene	µg/l	--	--	--	--	--	10
Styrene	µg/l	--	--	--	--	--	37
Tetrachloroethene	µg/l	<2.8	430	69	--	--	--
Toluene	µg/l	<2.8	260	66	--	--	149
Trichloroethane, 1,1,1-	µg/l	<3.2	618	134	--	--	28
Butanone, 2- (MEK)	µg/l	<14	179	40	--	--	--
Hexanone, 2-	µg/l	--	--	--	--	--	103
Dichloroethane, 1,1-	µg/l	<2.8	390	48	--	--	--
Carbon Disulfide	µg/l	<10	650	171	--	--	--
Xylenes (total)	µg/l	<3.2	1,900	479	--	--	--
1,2,3,7,8-PCDF	ppt	<0.32	65.9	33.1			
2,3,4,7,8-PCDF	ppt	8.78	180.4	94.6			
Total PCDF	ppt	127.1	407.9	267.5			
1,2,3,7,8-PCDD	ppt	<6.14	10.7	8.42			
Total PCDD	ppt	37.6	66.9	52.2			
2,3,4,6,7,8-HxCDF	ppt	<0.87	211.7	106.3			
1,2,3,7,8,9-HxCDF	ppt	<0.91	73.1	37.0			
Total HxCDF	ppt	180.8	2,388	1,284			
1,2,3,6,7,8-HxCDD	ppt	36.5	2,542	1,289			
1,2,3,7,8,9-HxCDD	ppt	<1.49	292.6	147.0			
Total HxCDD	ppt	289.5	9,932	5,111			
1,2,3,4,6,7,8-HpCDF	ppt	50.3	2,742	1,396			
Total HpCDF	ppt	204.4	8,367	4,286			
1,2,3,4,6,7,8-HpCDD	ppt	668.7	82,636	41,652			
Total HpCDD	ppt	1,291	185,173	93,232			
2,3,7,8-TCDF	ppt	<0.53	112.2	56.4			
Total TCDF	ppt	113.0	146.7	129.8			
2,3,7,8-TCDD	ppt	<12.5	115.4	64.0			
OCDF	ppt	214.8	1,701	957.9			
OCDD	ppt	7,595	1,086,585	547,090			

NOTES:

(1) The sludge data presented are based on the sampling results of three aqueous hazardous waste treaters with physical/chemical treatment: 2 sites, Sites J and L, in the EPA-ITD sampling effort and one site in the OSW sampling program. All samples were collected at the discharge of sludge thickening/dewatering facilities. One sludge sample was collected from each of the EPA-ITD sampled sites, 11 sludge samples were collected in the OSW program. All sludge data is contained in Appendix C.

(2) Metals concentrations in mg/kg wet basis, organics in µg/l, and dioxins/furans in ppt, as indicated. All toxicity characteristic leaching procedure (TCLP) concentrations in µg/l.

organic compounds were detected in the sludges. Eight compounds were found at concentrations above 10,000 µg/l, indicating significant removal of some organics by chemical precipitation/sedimentation technologies. Adsorption on the solids is a probable removal mechanism. Acetone, a volatile compound that showed a relatively high average percent removal, was found to be concentrated in the sludge, showing that volatilization is not the only removal mechanism for certain volatile pollutants.

The most significant item in the sludge analyses is the large number and high concentration of dioxins/furans. Thirteen individual isomers were identified at concentrations ranging from <0.32 ppt to 1.087 ppm. The isomers included 2, 3, 7, 8-TCDD, the most toxic dioxin known. Its concentration in one sludge was 115 ppt, which is extremely high. No dioxins/furans analyses were performed on the raw wastes or the treated effluents; however, most dioxins are relatively insoluble and tend to adsorb on particulates. Significant TSS concentrations in the treated effluents discharged from aqueous hazardous waste treaters could indicate the discharge of significant concentrations of dioxins/furans.

6.3.3 Advanced Treatment

Three aqueous hazardous waste treaters operated advanced wastewater treatment systems. Only one facility provides reduction/oxidation followed by chemical precipitation, clarification, sand filtration, carbon adsorption, biological treatment, and polishing ponds before discharging directly to surface water. At another facility, inorganic wastes are pretreated with chemical precipitation and mechanical filtration (filter press) prior to mixing with other wastes. The combined wastes then undergo biological treatment, filtration, carbon adsorption, and polishing in holding ponds prior to discharge to a POTW. The third facility pretreats cyanide wastes prior to combining them with other wastes for chemical precipitation, mechanical filtration (filter press), sand filtration, and carbon adsorption prior to discharge to a POTW.

6.3.3.1 Treated Effluent Data

Table 6-13 presents summary concentration and percent removal data for pollutants found in the effluents of advanced treatment systems. Even with biological treatment, relatively poor removals of BOD_5, COD, and TOC were found. Not only were the percent removals of the pollutants poor, but high effluent concentrations were the norm. The advanced treatment systems also provided poor TSS removals with the effluent concentrations averaging 480 mg/l. Intermediate data showed that the ponds did not contribute TSS to the effluents. Poor reductions resulted in high effluent ammonia

TABLE 6-13. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM EFFLUENTS - AQUEOUS TREATERS SUBCATEGORY(2)

	Effluent Concentration(1)			
Pollutant	Minimum	Maximum	Mean	Mean % Removal(3)
BOD5, mg/l	30	2,340	1,013	57
COD, mg/l	250	5,820	2,944	63
TOC. mg/l	40	1,500	966	53
TSS. mg/l	60	980	480	54
Ammonia, mg/l	0.1	650	186	57
TKN, mg/l	1.5	1,170	577	48
O&G, mg/l	1.0	18.2	9.9	84
Phenols, mg/l	0.05	35.4	10	48
Cyanide, mg/l	0.02	0.19	0.11	80
Fluoride, mg/l	0.4	14	7.4	57
Boron	3,000	15,400	8,403	43
Barium	106	1,090	552	28
Iron	361	3,550	1,946	63
Manganese	184	2,580	1,345	50
Zinc	56	1,600	634	75
Nickel	686	2,200	1,285	79
Aluminum	27	857	440	50
Lead	560	740	640	85
Cadmium	<5	1,400	303	68
Molybdenum	66	627	329	56
Tin	<13	<40	(4)	50
Cobalt	7.8	7.8	7.8	53
Chromium	60	120	84	82
Copper	20	870	307	84
Titanium	<10	<50	(4)	50
Silver	<1	<5	(4)	50
Arsenic	30	124	76	57
Antimony	14	77	46	64
Mercury	<0.2	6	2.1	88
Vanadium	3.2	3.4	3.3	50
Acetone	<50	160,000	76,621	33
Acrolein	<50	839	247	0
Chloroform	<10	111	35	50
Methylene Chloride	<10	30,000	6,015	58
Trans-1,2-Dichloroethene	<10	28	14.5	68
Trichloroethene	<10	12	10.5	94
Vinyl Acetate	48	407	228	0
Dichloroethene, 1,1-	<10	16	11.5	49

TABLE 6-13. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM EFFLUENTS - AQUEOUS TREATERS SUBCATEGORY(2) (Continued)

	Effluent Concentration(1)			
Pollutant	Minimum	Maximum	Mean	Mean % Removal(3)
Trichloroethane 1,1,2-	<10	556	187	47
Tetrachloroethane, 1,1,2,2-	<10	241	91	50
Dichloroethane, 1,2-	<10	78	27	69
Butanone, 2- (MEK)	<50	5,437	1,397	82
Thioxanthone	222	293	258	50
Butyl Benzyl Phthalate	<10	100	40	0
Di-n-Butyl Phthalate	<10	120	47	0
Trichloroethane, 1,1,1-	<10	1600	328	90
Benzene	<10	<10	<10	82
Carbon Tetrachloride	<10	<10	<10	78
Chlorobenzene	<10	<10	<10	78
Ethylbenzene	<10	<10	<10	68
N-Dodecane (N-C12)	<10	<10	<10	79
Tetrachloroethene	<10	<10	<10	81
Toluene	<10	<10	<10	79
Dichloroethane, 1,1-	<10	<10	<10	49
Benzoic Acid	<10	<10	<10	99
P-Cresol	<10	<10	<10	73
Diethyl Ether	<50	96	62	12
Isophorone	--	--	5.5	29
Phenol	<10	<100	(4)	98
Chloro-3-Methyl Phenol, 4-	<10	<100	(4)	48
Alpha-Terpineol	<10	548	189	0
O-Cresol	<10	<10	<10	21
Hexanoic Acid	<10	<10	<10	98
2-4-D	<5	<5	<5	81
Aldrin	<0.2	<0.2	<0.2	91
Endosulfan II	<0.5	<0.5	<0.5	75
Heptachlor	<0.2	<0.2	<0.2	82
OCDF, ppt	--	--	0.15	--

TABLE 6-13. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM EFFLUENTS - AQUEOUS TREATERS SUBCATEGORY(2)
(Continued)

NOTES:

(1) All concentrations expressed in µg/l, unless otherwise noted.

(2) Data presented are the results of sampling at three aqueous hazardous waste treaters with advanced treatment systems: Site K provided reduction/oxidation, chemical precipitation, clarification, filtration, carbon adsorption, biological treatment and polishing ponds; Site M treatment included pretreatment of inorganic wastes, biological treatment, filtration, carbon adsorption, and polishing; and the OSW site pretreated cyanide wastes, followed by chemical precipitation, filtration, and carbon adsorption. All sampling data for these three sites are contained in Appendix C.

(3) Mean % removal was calculated using the sampling data from all three aqueous treaters with advanced treatment systems based on the following formula:

$$\text{Mean \% Removal} = \frac{\displaystyle\sum_{i}^{n} \frac{(\text{mean influent} - \text{mean effluent})}{\text{mean influent}} \times 100}{n}$$

Where mean influent is the raw waste water concentration calculated for each site. Mean effluent is the final treated site effluent also calculated for each site. Influent and effluent data for these sites are contained in Appendix C.

n = 3, the number of aqueous hazardous waste treaters with advanced treatment in the data base.

For those pollutants whose effluent concentrations were reported less than the detection limit (for example, ethylbenzene <10 µg/l), the detection limit (10 µg/l) was used in the calculation.

(3) Mean effluent concentrations are not presented for those pollutants where all effluent concentrations were below the detection limit and different detection limits were reported for the three sites.

and TKN concentrations, but none of the treatment systems were designed specifically for removal of these pollutants.

Metals

Iron, manganese, boron, barium, nickel, and zinc were found at concentrations above 1,000 µg/l in the treated effluent. Average removals of these metals ranged from 28 percent for barium to 79 percent for nickel. The advanced treatment system at the first facility reported lower concentrations of aluminum, manganese, barium, chromium, copper, iron, and nickel after intermediate steps in the treatment system than in the final effluent. Based on mean effluent concentrations, the physical/chemical treatment systems discussed in Section 6.3.2 produced lower cadmium, mercury, copper, nickel, barium, and lead concentrations. Mean effluent concentrations of zinc, aluminum, chromium, iron, and boron were lower in the advanced treatment systems.

Organic Pollutants

Nineteen organic pollutants were detected in the effluents from the advanced treatment systems, but only 4 had concentrations above 1,000 µg/l compared to 14 in the physical/chemical system effluents. In addition, another 13 organic compounds detected in the raw wastes were reported below detection levels in the treatment system effluents. Average removal of these compounds ranged from 8 to 98 percent. Although 8 of the 13 compounds are volatiles, the average percent removals of the volatiles were lower than those of the nonvolatiles, which indicates that removal mechanisms other than volatilization are effective in the advanced treatment systems.

Only five compounds averaged zero percent reduction through the advanced treatment systems, including some with raw waste concentrations below their detection limits. Such data may be the result of detention times in the treatment systems and/or analytical difficulties, both of which affect the estimates of actual removals of organic pollutants in wastewater treatment systems.

6.3.3.2 Residuals Data

The concentrations of pollutants reported in sludges from advanced treatment systems, as shown in Table 6-14, are limited to data from only one facility, the one with chemical precipitation, filtration, and carbon adsorption. Consequently, the sludges are chemical sludges rather than the chemical/biological sludges generated by the other two advanced treatment systems.

TABLE 6-14. CONCENTRATIONS OF POLLUTANTS IN ADVANCED TREATMENT SYSTEM SLUDGES - AQUEOUS TREATERS SUBCATEGORY(1)

		Sludge Sample			Results of TCLP (µg/l)(3)		
Pollutant	Units(2)	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Cadmium	mg/kg	2,900	12,000	7,200			
Chromium	mg/kg	0.068	23,000	11,700			
Copper	mg/kg	380	50,000	39,300			
Lead	mg/kg	790	1,300	973			
Nickel	mg/kg	1,400	9,300	5,700			
Zinc	mg/kg	4,000	35,000	17,700			
Cyanide	mg/kg	400	950	667			
Acetone	µg/l	--	--	260,000	--	--	--
Methylene Chloride	µg/l	61,000	79,000	70,000	--	--	2,800
Trichloroethene	µg/l	73,000	400,000	194,300	--	--	1,700
Toluene	µg/l	290,000	1,400,000	756,700	--	--	7,200
Chlorobenzene	µg/l	11,000	34,000	20,000	--	--	240
Ethylbenzene	µg/l	55,000	110,000	79,300	--	--	520
Total Xylenes	µg/l	300,000	720,000	530,000	--	--	3,200
Naphthalene	µg/l	--	12,000	--	--	--	--
Bis(2-Ethylhexyl)Phthalate	µg/l	22,000	200,000	111,000	--	--	--
Di-N-Butyl Phthalate	µg/l	--	15,000	--	--	--	--
Trichloroethane, 1,1,1-	µg/l	110,000	160,000	135,000	--	--	3,100
Tetrachloroethene	µg/l	74,000	100,000	87,000	--	--	660
Chloroform	µg/l	--	--	--	--	--	300

NOTES:

(1) Data presented are the results of sludge samples taken from the OSW sampling facility with advanced treatment. Treatment at this facility includes pretreatment of cyanide wastes prior to chemical precipitation, filtration, and carbon adsorption. The sludge samples were collected from the sludge filter press.

(2) Metals concentrations in mg/kg wet basis and organics in µg/l. All TCLP concentrations in µg/l.

(3) TCLP = toxicity leaching characteristic procedure.

Cadmium, chromium, copper, and zinc were found at concentrations above 10,000 mg/kg in the sludges. Sludge concentrations of 12 organic compounds were also high. Because the sludges only were tested for 6 metals and 93 organic compounds, it is likely that other organics and metals also were present. In addition, high detection limits resulted in only 12 of the 93 organics tested being found at reportable concentrations.

The TCLP concentrations of the organic compounds were relatively low, considering the corresponding compositional analyses. No dioxins/furans analyses were performed on the sludges.

6.3.4 Conclusions

Aqueous hazardous waste treatment systems range from chemical precipitation/sedimentation units to advanced secondary and tertiary treatment systems.

Although the physical/chemical treatment technologies in-place at aqueous hazardous waste treaters are designed for removal of metals and other inorganic pollutants, the wastes accepted by these facilities contain significant quantities of toxic organics that pass through the treatment systems, receiving limited treatment. The poor treatment received by organics is reflected in the BOD_5, TOC, and COD removals. Large reductions in heavy metals are achieved by the treatment systems, even for metals found in low concentrations in the raw wastes. Only five metals were found in concentrations above 1,000 μg/l in treated effluent.

Compared to the physical/chemical treatment systems in-place at some aqueous hazardous waste treaters, the advanced treatment systems are more effective in removing organic compounds; however, high effluent concentrations of organic compounds are common even with advanced treatment. This conclusion is supported by high effluent concentrations of indicator compounds such as BOD_5, TOC, and COD, which show relatively poor removals. Advanced treatment systems demonstrated metals removal efficiencies and effluent concentrations similar to those achieved by physical/chemical treatment systems.

Due to detention times in treatment systems and the limited number of samples collected at each facility, it was difficult to pair influent and effluent concentrations of pollutants to estimate percent removals. In an attempt to overcome this obstacle, influent and effluent concentrations were averaged, but even this procedure resulted in negative percent removals in some cases. Negative percent removals were assumed to be zero percent removal when discussing the effectiveness of treatment technologies.

Both physical/chemical and advanced treatment technologies provided relatively poor removal of BOD_5, TOC, COD, TSS, ammonia, and TKN. High effluent concentrations of other pollutants also were found. These results are typical for physical/chemical treatment systems designed to remove inorganic pollutants, primarily metals. The relatively poor removal of TOC and BOD_5 by advanced treatment systems using biological treatment and/or carbon adsorption indicates the potential for discharge of poorly treated hazardous wastes to POTWs or surface waters.

Based on the plants sampled, many of the toxic organic pollutants accepted by aqueous hazardous waste treatment facilities were not effectively removed by physical/chemical or advanced treatment systems. Effluent concentrations of individual organic compounds can exceed 10,000 µg/l, even with advanced treatment technologies such as carbon adsorption. Biological treatment was also relatively ineffective in the treatment of some organic compounds. However, better performance is expected from these treatment technologies, and the poor performance observed in the sampled plants is believed attributed to the small data base.

No significant differences between the effectiveness of physical/chemical and advanced treatment technologies in removal of metals was demonstrated by the treatment systems investigated. The advanced treatment systems demonstrated better removals and lower effluent concentrations for certain metals, while the physical/chemical treatment systems were better for others. Whether these results are indicative of the effectiveness of the types of treatment technologies or the result of raw waste types and concentrations of metals in them has not been established.

A critical question raised by the data presented in this section is the potential for the discharge of dioxins/furans from aqueous hazardous waste treaters to POTWs and surface waters. The effluent samples were not tested for dioxins/furans, but extremely high concentration of a large number of isomers were found in the sludges. Dioxins/furans are relatively insoluble in water and tend to adsorb on particulates. High effluent TSS concentrations were found from both physical/chemical and advanced treatment systems, which indicates the potential for the discharge of these isomers. Sampling and testing of treatment system effluents for dioxins/furans is necessary to establish the concentrations of these compounds in treated effluent and the effectiveness of various treatment systems for their removal.

7. COST OF WASTEWATER CONTROL AND TREATMENT

This section presents estimates for the cost of implementation of wastewater treatment control for each of the subcategories included in the hazardous waste treatment (HWT) industry. The cost estimates provided the basis for the determination of the probable economic impact of regulation.

To arrive at the cost estimates presented in this section, specific waste treatment technologies were selected that correspond to the common types of facilities operating within the HWT industry as found in Table 7-1. The raw wastewater characteristics selected were based on the range of pollutant concentrations found during sampling efforts. Wastewater flow rates used in sizing the equipment are typical rates found within treatment systems used for costing.

The cost estimates include both investment and operating costs. Investment costs were determined by estimating the costs of individual unit operations. These estimates were derived from development documents for industries treating similar wastes, other U.S. Environmental Protection Agency (EPA) reference material, textbooks, manufacturer's literature, and vendor quotations. A piping cost for intercomponent piping, valves, and piping required to transfer the wastewater to the treatment system was estimated as a percentage (10%) of the total equipment cost.

As a part of the investment cost, it was assumed that a building would be necessary to: (1) house the majority of the unit operations, (2) house the system instrumentation, (3) store treatment chemicals and other supplies, and (4) as a base for operation and maintenance activities.

Several other cost elements were estimated as a percentage of the total capital costs. An equipment, piping, and building contingency of 10 percent was used to account for varied requirements at specific locations. In addition, an engineering design fee of 10 percent was included to account for the overall design of the process and engineering supervision required during installation and start-up of the equipment. Inspection fees (2%) also were added to the total investment cost (TIC).

Operating costs were estimated by adding together the expected annual costs for various operating cost elements. A labor estimate was made based on expected requirements for the entire facility rather than for individual units. An overhead rate of 50 percent was added to the salaries to account for employee benefits and employment costs (e.g., social security, medical benefits, and unemployment tax) incurred by the facility. Energy costs were calculated based on the expected requirements for each unit

TABLE 7-1. DESIGN BASIS FOR TREATMENT SYSTEM COST ESTIMATES

Aqueous Hazardous Waste Treaters Subcategory

Design flow rate of 45,500 gpd (see Figure 7-1)

Facility operates 24 h/d, 5 d/wk, 260 d/y
- no weekend operation

Waste volumes received are evenly divided into five types each with an average flow of 10,000 gpd:

- Chromate wastes
- Metal wastes
- Cyanide wastes
- Oily wastes
- Organic wastes

The characteristics of each waste category are as follows:

chromate wastes
1297 mg/l Cr +6

metal wastes
113 mg/l Cd
753 mg/l Cu
3,286 mg/l Zn
1,577 mg/l Ni
107 mg/l Pb

cyanide waste
225 mg/l CN

oily waste unspecified

organic waste
1,000 mg/l COD

Leachate Treatment Subcategory

Design flow of 30,000 gpd (see Figure 7-2)

Facility operates 24 h/d, 5 d/wk, 260 d/yr
- no weekend generation

Weekend flow is stored in aerated equalization tank (Required since leachate is continuously generated and only treated 5 days/week)

Raw waste characteristics are as follows:

pH = 7.0
COD = 500-25,000 mg/l
Total metals = 426 mg/l

TABLE 7-1. DESIGN BASIS FOR TREATMENT SYSTEM COST ESTIMATES (Continued)

Scrubber Wastewater Subcategory

Design flow of 900,000 gpd/93,000 gpd (see Figure 7-3)

Facility operates 24 h/d, 5 d/wk, 300 d/yr
- no weekend operation

The waste volume of scrubber blowdown was 900,000 gpd

Raw waste characteristics are as follows:

pH = 0.1 to 2.0
TSS = 10,000 mg/l
Temp = 80°C
Total Metals = 424 mg/l

---

operation considering hydraulic loading and air requirements. Energy costs primarily include electrical requirements for pumps, blowers, and mixers. Chemical and material costs also were determined for each unit operation based on flow rate and waste characteristics. Sludge disposal costs were based on calculated sludge volumes, current average disposal rates for hazardous and nonhazardous wastes, and a unit cost of $.27 per gallon. This unit cost was on the low side of the wide range of reported sludge disposal costs. Use of a low cost, for purposes of this study, is appropriate since owners/operators of HWT facilities are likely to dispose of the sludge on-site or choose a least-cost means of disposal. Several other operating cost elements were included as a percentage of the TIC, including administration (5%), laboratory (2%), and taxes (1%).

All investment and operating costs were adjusted to 1987 (March) dollars using the CE plant cost index.

The three model treatment systems used as a basis for estimating the cost of wastewater treatment for each of the industry subcategories are presented in Figures 7-1 through 7-3. A summary of the cost estimates is shown in Tables 7-2 through 7-4. Assumptions used in estimating the treatment costs for each subcategory are contained in Appendix D.

7.1 AQUEOUS TREATERS SUBCATEGORY

Unlike the other subcategories of the HWT industry, the production facility cannot be separated from the wastewater treatment system in the aqueous treaters subcategory. Consequently, the pollution control and treatment technology costs are the same as the costs for the actual production facility. For an average size facility (45,500 gpd) as shown in Figure 7-1, the investment cost was estimated at $767,000. Annual operating costs are estimated at $325,000 per year.

7.2 LEACHATE TREATMENT SUBCATEGORY

Based on average flow of 30,000 gpd, the investment cost for the model leachate treatment facility shown in Figure 7-2 was estimated at $806,000. Annual operating costs were approximately $286,000 per year. The model facility is designed to remove both inorganic and organic BAT pollutants. Costs for less sophisticated treatment systems can be estimated by eliminating individual unit process costs from Table 7-3.

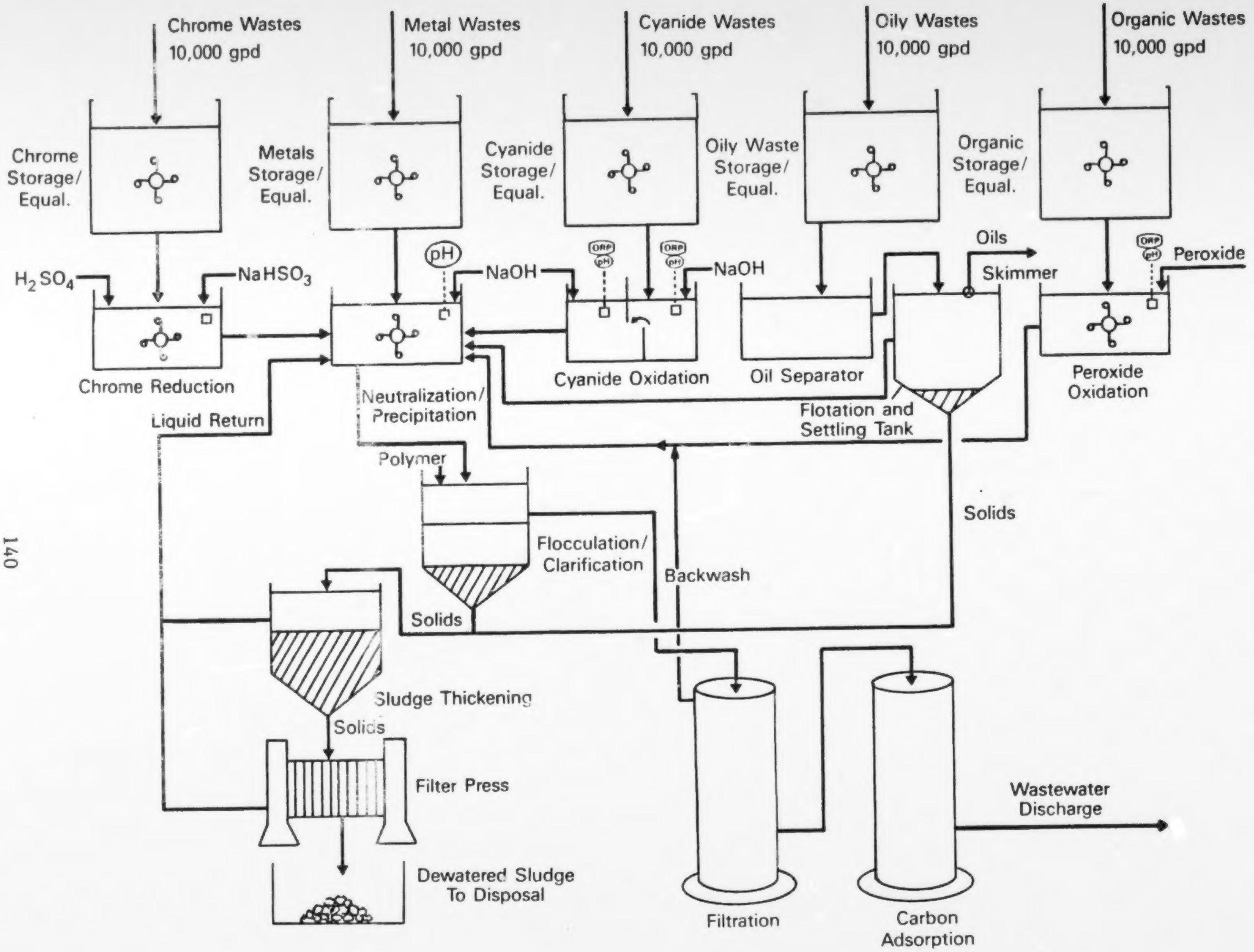
Chrome Wastes
10,000 gpd
Metal Wastes
10,000 gpd
Cyanide Wastes
10,000 gpd
Oily Wastes
10,000 gpd
Organic Wastes
10,000 gpd
Chrome Storage/ Equal.
Metals Storage/ Equal.
Cyanide Storage/ Equal.
Oily Waste Storage/ Equal.
Organic Storage/ Equal.
pH
ORP
pH
Oils
Skimmer
Peroxide
H_2SO_4
$NaHSO_3$
NaOH
NaOH
Chrome Reduction
Cyanide Oxidation
Oil Separator
Peroxide Oxidation
Liquid Return
Neutralization/ Precipitation
Flotation and Settling Tank
Polymer
Solids
Flocculation/ Clarification
Backwash
Solids
Sludge Thickening
Solids
Filter Press
Wastewater Discharge
Dewatered Sludge To Disposal
Filtration
Carbon Adsorption

Figure 7-1. Model Aqueous Waste Treatment System

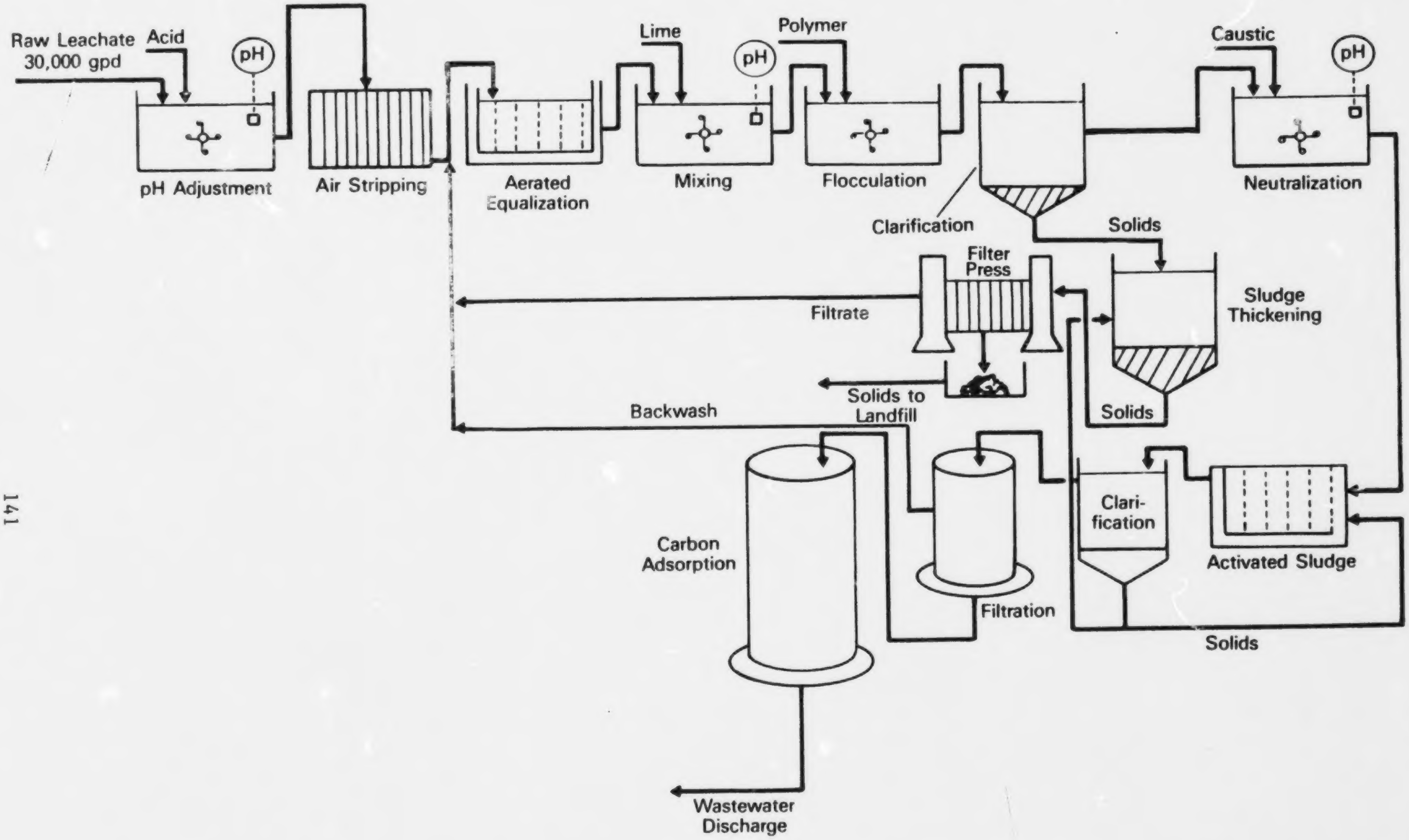
Raw Leachate
30,000 gpd
Acid
pH
pH Adjustment
Air Stripping
Aerated
Equalization
Lime
pH
Mixing
Polymer
Flocculation
Clarification
Caustic
pH
Neutralization
Solids
Filter
Press
Filtrate
Sludge
Thickening
Solids to
Landfill
Backwash
Solids
Clari-
fication
Activated Sludge
Carbon
Adsorption
Filtration
Solids
Wastewater
Discharge

Figure 7-2. Model Leachate Treatment System

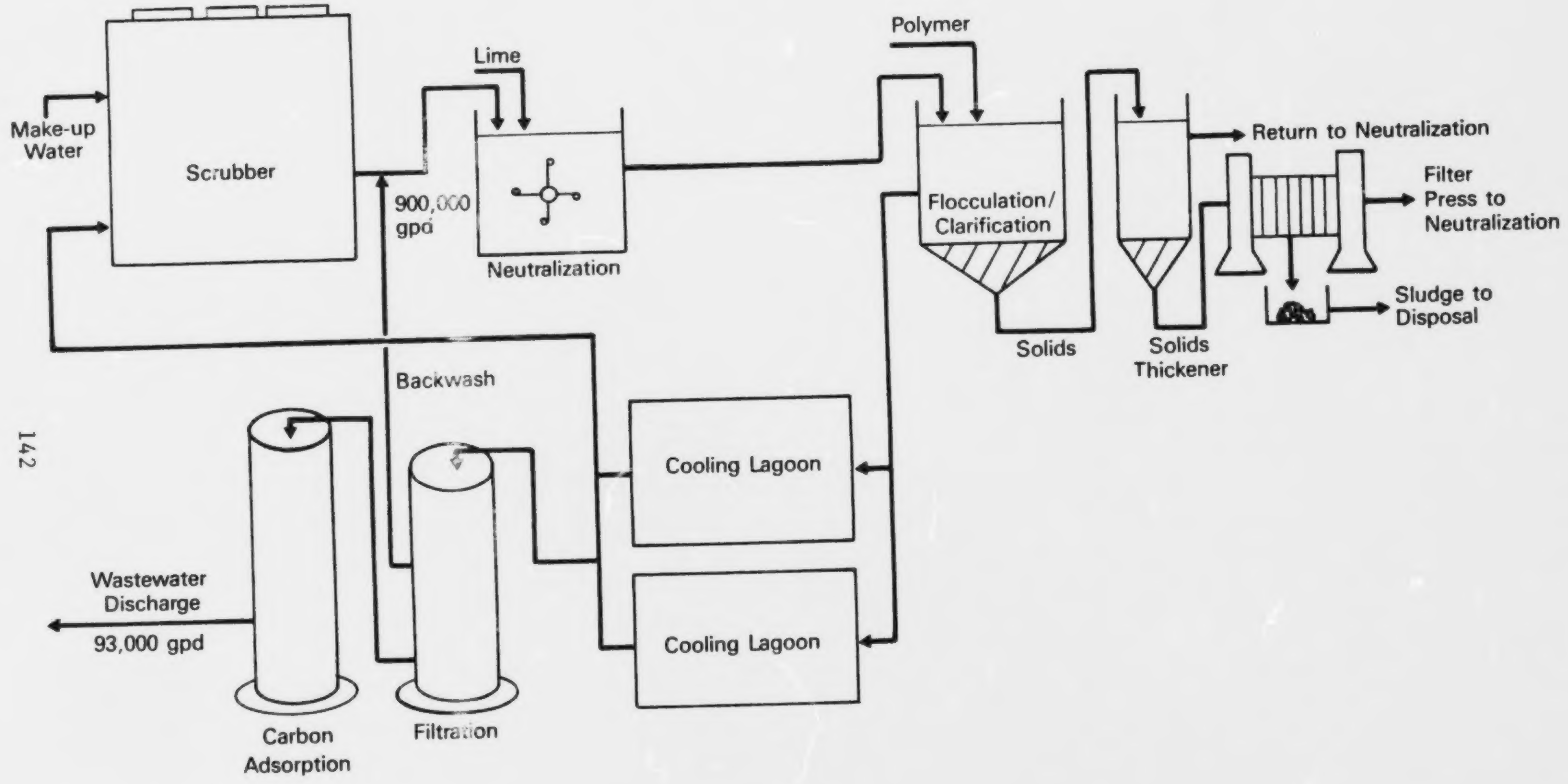
Make-up Water
Scrubber
900,000 gpd
Lime
Neutralization
Polymer
Flocculation/ Clarification
Solids
Solids Thickener
Return to Neutralization
Filter Press to Neutralization
Sludge to Disposal
Backwash
Cooling Lagoon
Cooling Lagoon
Wastewater Discharge
93,000 gpd
Carbon Adsorption
Filtration

Figure 7-3. Model Scrubber Wastewater Treatment System

TABLE 7-2. MODEL AQUEOUS TREATMENT SYSTEM COSTS

Investment Cost

System Component	Cost, 1987 $
Storage/Equalization (5-5,000 gal)	23,500
Chrome Reduction	19,600
Cyanide Oxidation	18,600
Neutralization/Precipitation	29,400
Flocculation/Clarification	39,200
Filtration	45,500
Carbon Adsorption	260,000
Sludge Storage/Thickening	21,700
Filter Press	51,450
Oil Separator	34,600
Equipment Subtotal ....>	543,550
Piping (10% of equipment)	54,355
Building (1,000 sq.ft. @ $75/sq.ft.)	75,000
Subtotal for Building and Equipment ....>	618,550
Contingency (10% of B&E subtotal)	61,855
Engineering Design (10% of B&E subtotal)	61,855
Inspection Fees (2% of B&E subtotal)	12,371
Administration/Legal Fees (2% of subtotal)	12,371
Total Investment Cost (TIC) ....>	767,002

Operating Cost

Operating Cost Element	Annual Cost, 1987 $
O&M Labor (8,000 hrs @ $18/hr, include 50% OH)	91,900
Energy	5,100
Chemicals and Materials	103,600
Sludge Disposal	25,000
Administration (5% of TIC)	38,350
Laboratory (2% of TIC)	15,340
Equipment Replacement (5% of TIC)	38,350
Insurance and Taxes (1% of TIC)	7,670
Total Operating Cost ....>	325,310

TABLE 7-3. MODEL LEACHATE TREATMENT SYSTEM COSTS

Investment Cost

System Component	Cost, 1987 $
Aerated Equalization	87,100
Mixing	22,500
Flocculation/Clarification	30,400
pH Adjustment	22,500
Air Stripping	29,890
Neutralization	22,500
Activated Sludge/Clarification	80,000
Filtration	33,500
Carbon Adsorption	135,300
Sludge Thickener	19,600
Filter Press	39,200
Equipment Subtotal ....>	522,490
Piping (10% of equipment)	52,249
Building (1,000 sq.ft. @ $75/sq.ft.)	75,000
Subtotal for Building and Equipment ....>	64,739
Contingency (10% of B&E subtotal)	64,974
Engineering Design (10% of B&E subtotal)	64,974
Inspection Fees (2% of B&E Subtotal)	12,995
Administrative/Legal Fees (2% of subtotal)	12,995
Total Investment Cost (TIC) ....>	805,676

Operating Cost

Operating Cost Element	Annual Cost, 1987 $
O&M Labor (8,000 hrs @ $18/hr, include 50% OH)	144,000
Energy	16,100
Chemicals and Materials	6,700
Sludge Disposal	14,000
Administration (5% of TIC)	40,284
Laboratory (2% of TIC)	16,114
Equipment Replacement (5% of TIC)	40,284
Insurance and Taxes (1% of TIC)	8,057
Total Operating Cost ....>	285,538

TABLE 7-4. MODEL SCRUBBER TREATMENT SYSTEM COSTS

Investment Cost

System Component	Cost, 1987 $
Neutralization/Clarification	571,000
Cooling Lagoons (2-3 ft deep x 142'x 142')	60,400
Filtration	65,700
Carbon Adsorption	335,000
Sludge Thickener	22,500
Filter Press	46,000
Equipment Subtotal ....>	1,032,100
Piping (10% of equipment)	103,210
Building (1,000 sq. ft. @ $75/sq. ft.)	75,000
Subtotal for Building and Equipment ....>	1,210,310
Contingency (10% of B&E subtotal)	121,031
Engineering design (10% of B&E subtotal)	24,206
Inspection Fees (2% of B&E subtotal)	24,206
Administration/Legal Fees (2% of subtotal)	24,206
Total Investment Cost (TIC) ....>	1,500,784

Operating Cost

Operating Cost Element	Annual Cost, 1987 $
O&M Labor ($18/hr, including 50% OH)	144,000
Energy	13,800
Chemicals and Materials	9,500
Sludge Disposal	18,252
Administration (5% of TIC)	75,039
Laboratory (2% of TIC)	30,016
Equipment Replacement (5% of TIC)	75,039
Insurance and Taxes (1% of TIC)	15,008
Total Operating Cost ....>	380,654

7.3 SCRUBBER WASTEWATER SUBCATEGORY

For the scrubber wastewater subcategory, two cost estimates were calculated, as shown in Table 7-4. The first estimate included the investment and operating cost for the entire scrubber wastewater treatment system, including neutralization/ clarification, cooling lagoons, filtration, carbon adsorption, sludge thickening, and filter press, as shown in Figure 7-3. These system components, except for filtration and carbon adsorption, were related to the water reclamation system of the industrial process rather than the wastewater discharge system. Therefore, the second cost estimate only considered the wastewater portion of the facility.

The model scrubber wastewater treatment system assumed approximately 10 percent blowdown rate with treatment prior to discharge. Investment costs for the treatment system were estimated to be $1,501,000 and annual operating costs were estimated at $381,000 per year.

7.4 ECONOMIC ASSESSMENT AND COST EFFECTIVENESS

The purpose of this subsection is to assess the economic impacts that possible regulations would have on the HWT industry. An economic assessment is presented that compares the annualized cost of possible regulations to revenues currently realized by typical facilities in the industry. Cost-effectiveness was determined to identify the incremental annualized cost of subcategorical pollution control options per incremental pound equivalent of pollutant removed by that control option.

For purposes of an economic evaluation, four model plants were developed, representing an incinerator, a municipal landfill, a hazardous waste landfill, and an aqueous waste treater. Since detailed economic and technical data were not available at that time, these models are only for preliminary economic assessment. Capital and operating costs for typically sized model plants are presented in Table 7-5. Capital and operating and maintenance (O&M) costs were presented earlier in this section. The cost of land was estimated at 20 percent of the capital costs, and annual monitoring costs were estimated at $5,000. The annualized cost equals the sum of O&M and monitoring costs, plus the annual portion of capital and land costs, assuming a capital recovery factor of 0.26 (which corresponds to a discount rate of 10 percent and 5 years). These costs also are presented in Table 7-5.

7.4.1 Preliminary Economic Impact Assessment

Economic assessment impacts were measured by the ratio of treatment costs to revenues. Using a high, low, and average fee,

TABLE 7-5. MODEL FACILITIES AND COSTING*

		Control Cost ($1,000)				
Subcategory	Model Capacity	Investment	Land	O&M	Monitor	Annual**
Incinerator	18,000 mt/y	1501	300	381	5	854
Landfill Municipal	62 acres	806	161	286	5	542
Hazardous Waste Landfill	62 acres	806	161	286	5	542
Aqueous Treater	45,500 gpd for 260 d/y	767	153	325	5	569

* These model plant sizes are used for preliminary economic analysis only.

** Capital recovery factor is 0.26.

revenues were estimated for each model facility based on its capacity as follows (Ref. 31):

- Incinerator - $26 to $3,300 per metric ton, or an average $1,000 per metric ton ($3.80 per gallon)
- Aqueous waste treater - $0.12 to $6 per gallon, or an average $1.60 per gallon
- Hazardous waste landfill - $76 to $658 per metric ton, or an average $120 per metric ton
- Municipal landfills - $3 to $41 per metric ton, or an average $13 per metric ton

Revenue and treatment cost estimates were calculated on an annual basis for incinerators and aqueous treaters. However, for hazardous and municipal landfills, monitoring and treatment of leachate must continue for some time after dumping, as long as toxic leachate is generated. The cost of leachate treatment was assumed to continue for 20 years after the initial dumping, even if the site is closed. The revenue for the 62-acre model landfill assumes that the landfill is filled to its lifetime capacity (62 acres times 12,100 metric ton per acre) in the initial year. The present value of the lifetime leachate treatment costs include initial capital and land costs of $967,000, as shown in Table 7-5, plus the present value of O&M and monitoring for the next 20 years, discounted at 10 percent.

Table 7-6 presents the estimates of treatment cost in relation to revenues. For incinerators and aqueous treaters, the treatment costs and revenues are in annual terms. While the average ratio for incinerators was 4.7 percent, the ratio ranges from a low of 1.4 percent for incinerators charging the highest fees to 182.5 percent for incinerators charging the lowest fees. The impact of aqueous treaters was smaller: the average ratio was 3.0 percent, with a range from 0.8 percent for treaters charging high fees to 40.6 percent for treaters charging low fees.

For landfills, the revenue from landfilling a given amount of material was compared to the lifetime cost of treatment. For hazardous waste landfills, the ratio of the lifetime cost of treatment to revenue ranges from 0.7 to 6.0 percent with a ratio of 3.8 percent for a landfill charging average fees. Because of the low tipping fees at municipal landfills, the ratio of leachate treatment cost to revenues could be high, if such treatment is needed. The ratio of lifetime treatment cost to revenue ranges from 11.2 to 149.7 percent, with a cost to revenue ratio of 35.5 percent for those charging average fees.

TABLE 7-6 MODEL PLANTS OF HAZARDOUS WASTE TREATMENT FACILITIES AND CONTROL COST TO REVENUE COMPARISON

Subcategory	Capacity	Service fee		Revenu ($000)			Control cost ($000)		Control cost as % of fee (or revenue)
Incinerator	18,000 mt/y	High ($/mt)	3300	High	0	annually	854	annually	1.4
		Average	1000	Average	0	annually		annually	4.7
		Low	26	Low	0	annually		annually	182.5
Landfill Municipal	62 acres	High ($/mt)	41	High	30700	life	3444	life	11.2 **
		Average	13	Average	9700	life		life	35.5 **
		Low	3	Low	2300	life		life	149.7 **
Hazardous waste landfill	62 acres	High ($/mt)	658	High	495630	life	3444	life	0.7 **
		Average	120	Average	90000	life		life	3.8 **
		Low	76	Low	57000	life		life	6.0 **
Aqueous Treater	45,500 gpd for 260d/y	High ($/g)	6	High	71000	annually	569	annually	0.8
		Average	1.6	Average	18900	annually		annually	3.0
		Low	0.12	Low	1400	annually		annually	40.6

** Comparing life cycle cost with initial revenue (assuming a discount rate of 10 % in 20 years)

These ratios were based on tentative data. The municipal landfill results showed that only a small fraction (3.7 percent) were expected to require leachate treatment. This analysis should be further qualified because the wastewater treatment costs were assumed to be independent of the types of hazardous waste treated, so that for wastes having low disposal charges, the ratio of wastewater treatment costs to revenue were high. This can be misleading. For example, in the case of incinerators, scrubber water from incinerating highly toxic wastes is more likely to require treatment than scrubber water from incinerating high BTU wastes.

Based on this model plant analysis, the cost of treatment technologies appear to be modest in relation to revenue received by commercial hazardous waste treatment facilities with average fees. However, this is not the case for municipal landfills.

7.4.2 Cost-Effectiveness

Cost-effectiveness (CE) is defined as the incremental annualized cost of a pollution control option in an industry or industry subcategory per increments pound-equivalent of pollutant removed by that control option. The analysis accounts for differences in toxicity among the pollutants with toxic weighing factors (TWF) based on water quality criteria to protect aquatic and human health. Because concentration data are not always available for many priority and nonpriority hazardous pollutants, incremental removal may be underestimated in this preliminary CE calculation. A CE analysis was presented for each subcategory, based on performance data collected by EPA-ITD for the HWT industry. No distinction was made regarding direct/indirect discharge. The methodology for calculating cost effectiveness follows that employed for the Organic Chemicals Plastics and Synthetic Fibers (OCPSF) category.

7.4.2.1 Scrubber Wastewater Systems

The control technology shown in Figure 7-3 consists of two parts: (1) all units between neutralization and cooling pond inclusive - physical/chemical treatment, and (2) units downstream of the cooling pond-filtration/carbon adsorption. For 164 incinerators nationwide producing scrubber wastewater, the annual wastewater flow was 3,966 million gallons. Table 7-7 shows the data used and the step-by-step calculations for each pollutant. The incremental annual per plant treatment cost of $854,000 applied to each of the 164 plants gave an annual industry-wide treatment cost of $140 million. After calculating the sum of incremental removals (PE), a CE of $44.68 per pound equivalent removed was calculated. After treatment, the scrubber wastewater can be reused, thus avoiding costs incurred from obtaining new water.

TABLE 7-7 COST-EFFECTIVENESS CALCULATION FOR SCRUBBER WASTEWATER TREATMENT SYSTEMS

Number of plants (N)	164
Wastewater flow (gpd) @ each plant (q)	93,000
Number of days/year in operation (d)	260
Annual flow (mgy) for all plants = N x q x d	3,966

					Advanced treatment		
No.	Organic pollutant name	Raw waste conc.(ppb)	TWF	Weighted conc.(ppb)	% removal	efflu. conc. (ppb)	efflu. conc. wtd.
1.	Acetone	65	0	0	na	65	0
2.	Benzene	61	0.848	51.7	na	61	51.7
3.	Bromoform	15	0.0357	0.5	na	15	0.5
4.	Fluoranthene	109	0.104	11.3	83	18.5	1.9
5.	N-Nitrosodi-N-Propylamine	907	0.452	410.0	98	18.1	8.2
6.	Pyrene	326	0.146	47.6	94	19.6	2.9
7.	Thioxanthone	4067	0	0	90	406.7	0.0
	Sum	5,550		521		604	65
	Annual loading for all flow	184,000		17,000		184,000	2,000
No.	Metallic pollutant name						
1.	Antimony	1500	0.0036	5.4	90	150.0	0.5
2.	Arsenic	1040	32.0295	33310.7	99	10.4	333.1
3.	Cadmium	600	5.09	3054.0	89	66.0	335.9
4.	Chromium	970	0.0267	25.9	99	9.7	0.3
5.	Copper	6430	0.467	3002.8	99	64.3	30.0
6.	Lead	21200	1.75	37100.0	99	212.0	371.0
7.	Nickel	2310	0.114	263.3	89	254.1	29.0
8.	Zinc	159000	0.119	18921.0	99	1590.0	189.2
9.	Mercury	71	505.026	35856.8	99	0.7	358.6
10.	Selenium	6.6	0.16	1.1	na	6.6	1.1
11.	Thallium	11	0.257	2.8	na	11.0	2.8
	Sum	193,050		95,683		2,357	1,289
	Annual loading for all flow	6,385,000		3,164,000		78,000	43,000
	Organics plus metals	6,569,000		3,181,000			45,000
	Incremental removal (PE) for 164 plants						3,136,000
	Annualized costs for all plants						140,107,000
	CE ($/PE)						44.68

@ each plant:	investment ($)	1,501,000
	land costs (20% of above) ($)	300,200
	O&M cost ($/y)	381,000
	monitoring cost ($/y)	5,000
	annualized cost ($/y)	854,312

Credit in recycled scrubber water @ $1.2 per 1000 gallons	35,818,000
CE ($/PE) with credit in recycled scrubber water	33.26

Data sources: raw waste conc.(Tables 5-13 & 5-14), performance (Table 6-9).
na = not analysed.

With credit for water reuse, CE would be $33.26 per pound equivalent. In the calculation, it was assumed that 700,000 gpd of water from treatment are reused, with a value of $1.20 per 1,000 gallons.

7.4.2.2 Leachate Treatment Systems

Candidate control technology for the leachate treatment system is air stripping before an activated sludge process, followed by filtration/carbon adsorption. For 528 leachate collection systems in the United States, the annual leachate flow was 4,114 million gallons. Table 7-8 presents the data and calculations for the system. It should be noted that the Table5-8 was calculated using unedited data from Chapter 5. The data shown in Chapter 5 do not include "non-detects."

Because many pollutants are not always present in all leachate systems, a probability was used to represent the likelihood of the occurrence of a pollutant in the leachate system. For example, methylene chloride was observed in more than 50 percent of the samples in five out of six studies; the occurrence probability was 5/6 or 0.83. The probability of occurrence for each pollutant is also shown in Table 7-8.

This analysis incorporated the findings of the EPA Office of Air Quality Planning and Standards (OAQPS) by explicitly assigning removal efficiencies of air stripping and aerated equalization for removing VOCs (Ref. 32). Organic priority pollutants were classified into three groups; High-Henry's law constant, Medium Henry's law constant, and Low-Henry's law constant (Appendix H). The analysis assumed that the air stripping/aerated equalization removed and captured 90 percent of the first group, 70 percent of the second group, and none of the third group. The CE for this control option was $7.66 per pound equivalent removed. If the volatilized pollutants were not captured, then the CE was $71.60 per pound equivalent removed.

7.4.2.3 Aqueous Hazardous Waste Treaters

The model plant for aqueous waste treaters was composed of processes treating five wastestreams, each contributing 20 percent of the wastewater flow. Control option was pretreatment (including chromium reduction, cyanide destruction, oil skimming, and peroxide oxidation), followed by flocculation/clarification. For 602 aqueous hazardous waste treaters in the United States discharging wastewater, the annual flow was 7,122 million gallons. Table 7-9 summarizes the data and the calculations. Using removal efficiencies based on data collected for this analysis, the CE for this control option was $11.17 per pound equivalent removed.

TABLE 7-8 COST-EFFECTIVENESS CALCULATION FOR LEACHATE TREATMENT SYSTEMS

Number of plants (N)	528
Wastewater flow (gpd) @ each plant (q)	30,000
Number of days/year in operation (d)*	260
Annual flow (mgy) for all plants = N x q x d	4,118

No.	Pollutant	Toxic Weighting Factor	Proba-bility	Observed sample conc. (ppb)	Raw waste Expected conc. (ppm)	wtd.	Advanced treatment including modified air stripping and aerated equalization Removal	effluent conc. (ppb)	wtd.
01.	CH2CL2 (METH)	2.9470000	0.83	20135	16712	49250	0.7	5014	14775
02.	DCB, 1,2-	0.0170000	0.15	7839	1176	20	0.7	353	6
03.	TCA, 1,1,1-	0.0003000	0.15	5051	758	0	0.9	76	0
04.	TCE	0.2070000	0.15	8530	1280	265	0.9	128	26
05.	Chloroform	2.9520000	0.15	3769	565	1669	0.9	57	167
06.	Chlorobenz.	0.0115000	0.15	3288	493	6	0.9	49	1
07.	DCA, 1,2-	0.5960000	0.15	13990	2099	1251	0.7	630	375
08.	DCA, 1,1-	0.0005600	0.15	394	59	0	0.9	6	0
09.	DCB, 1,4-	0.0213000	0.15	1687	253	5	0.9	25	1
10.	TetraCE	0.7070000	0.15	6873	1031	729	0.9	103	73
11.	T,-1,2-DCE	0.0005000	0.15	387	58	0	0.9	6	0
12.	DCB, 1,3-	0.0180000	0.15	410	62	1	0.9	6	0
13.	CCL4	1.4000000	0.15	7763	1164	1630	0.9	116	163
14.	TCA, 1,1,2-	0.9340000	0.15	15898	2385	2227	0.7	715	668
15.	DCPP, 1,2-	0.0006900	0.15	54	8	0	0.7	2	0
16.	Chloronapthal	0.3500000	0.15	46	7	2	na	7	2
17.	Chloroethane	0.0000000	0.15	57	9	0	0.9	1	0
18.	Vinyl chloride	0.2800000	0.15	189	28	8	0.9	3	1
19.	TCA, 1,1,2,2-	3.2940000	0.15	114097	17115	56375	0.7	5134	16913
20.	Methyl bromide	2.9470000	0.15	170	26	75	0.9	3	8
21.	Methyl chloride	2.9470000	0.15	170	26	75	0.9	3	8
22.	DCE, 1,1-	16.9700000	0.15	99	15	252	0.9	1	25
23.	DCDFM	0.0357000	0.15	287	43	2	0.9	4	0
24.	Toluene	0.0004000	0.83	9552	7928	3	0.92	634	0
25.	Napthalene	0.0090300	0.15	1210	182	2	0.7	54	0
26.	Benzene	0.8480000	0.83	569	472	400	0.9	47	40
27.	Ethylbenzene	0.0040000	0.5	3769	1885	8	0.9	188	1
28.	Phenanthrene	0.0281000	0.15	69	10	0	0.7	3	0
29.	Acenaphthylene	0.0660000	0.15	56	8	1	0.7	3	0
30.	Nitrobenzene	0.0002830	0.15	15	2	0	na	2	0
31.	Anthracene	0.2440000	0.15	20	3	1	na	3	1
32.	Acenaphthene	0.9210000	0.15	45	7	6	0.7	2	2
33.	Fluoranthene	0.1040000	0.15	24	4	0	na	4	0
34.	C-3-methylphen	0.1806000	0.15	14	2	0	na	2	0
35.	Nitrophenol, 4-	0.0135000	0.15	17	3	0	na	3	0
36.	Isophorone	0.0000100	0.15	1133	170	0	na	170	0
37.	Di-n-butylphthalate	0.0001650	0.15	189	28	0	na	28	0
38.	Bis(2-eh) phthalate	2.1866700	0.15	934	140	306	na	140	306
39.	Dimethyl phthalate	0.0000179	0.15	517	78	0	na	78	0
40.	Di-n-oct phthalate	0.8115900	0.15	22	3	3	na	3	3
41.	Pyrene	0.1460000	0.15	25	4	1	na	4	1
42.	Benzo(a)anthracene	56.3590000	0.15	14	2	118	na	2	118
43.	Benzo(b)fluoranthen	26.0470000	0.15	11	2	43	na	2	43

TABLE 7-8 COST-EFFECTIVENESS CALCULATION FOR LEACHATE TREATMENT SYSTEMS (Continued)

44. Benzo(k)fluoranthen	2.3400000	0.15	11	2	4	0.7	0	1
45. Chrysene	0.1458000	0.15	16	2	0	na	2	0
46. Phenol	0.0021900	0.33	17390	5739	13	na	5739	13
47. Dimethylphenol	0.0026000	0.15	2498	375	1	na	375	1
48. DCPhenol, 2,4-	0.0170000	0.15	1240	186	3	na	186	3
49. PentaCphenol	1.7560000	0.15	445	67	117	na	67	117
50. TCphenol, 2,4,6-	0.4740000	0.15	3860	579	274	na	579	274
51. Chlorophenol, 2-	0.2150000	0.15	494	74	16	na	74	16
52. 2-ChloroEVE	0.0016000	0.15	70	11	0	na	11	0
53. Bis(2-CEOxy)methane	0.0000000	0.15	11	2	0	na	2	0
54. Bis(CM)ether	304.3470000	0.15	250	38	11413	0.7	11	3424
55. Diethyl phthalate	0.0000006	0.15	131	20	0	na	20	0
56. Butyl benzyl ph	0.0254500	0.15	141	21	1	na	21	1
57. Chlordane	2468.9920000	0.15	200	30	74070	na	30	74070
58. PCB-1016	7488.6080000	0.15	629	94	706550	na	94	706550
59. PCB-1242	7488.6080000	0.15	86767	13015	97464608	na	13015	97464608
60. PCB-1254	7488.6080000	0.15	700	105	786304	na	105	786304
61. Acrolein	0.2840000	0.15	487415	73112	20764	0.7	21934	6229
62. TCB, 1,2,4-	0.0200000	0.15	9748	1462	29	0.7	439	9
63. HCB	777.8000000	0.15	10000	1500	1166700	0.7	450	350010
64. HCE	0.3050000	0.15	10000	1500	458	0.7	450	137
65. HCButadiene	0.6130000	0.15	30000	4500	2759	0.9	450	276
66. BCMethane	2.9470000	0.15	130000	19500	57467	0.9	1950	5747
67. Fluorene	0.1120000	0.15	26	4	0	0.7	1	0
68. Acrylonitrile	0.8615300	0.15	4	1	1	0.7	0	0
69. Toxaphene	1197.8930000	0.15	1	0	180	na	0	180
70. Bis(2-CE)ether	0.4120000	0.15	10	2	1	na	2	1
71. Gama-BHC	78.9600000	0.15	5400	810	63958	na	810	63958
72. Alpha-BHC	18.0650000	0.15	7800	1170	21136	na	1170	21136
Sum (organic)			1,035,000	180,000	100,492,000		62,000	99,517,000
Pollutant weight in all flow			35,500,000	6,200,000	3,451,600,000		2,100,000	3,418,200,000
73. Antimony	0.0036200	0.5	396	198	1	0	198	1
74. Arsenic	32.0290000	0.5	15379	7690	246287	0.47	4075	130532
75. Cadmium	5.0900000	0.3	6623	1987	10113	0	1987	10113
76. Chromium	0.0267000	0.3	1067	320	9	0.66	109	3
77. Copper	0.4670000	0.62	835	518	242	0.32	352	164
78. Lead	1.7500000	0.62	993	616	1077	0	616	1077
79. Nickel	0.1140000	1	1202	1202	137	0.36	769	88
80. Zinc	0.1190000	1	25848	25848	3076	0	25848	3076
Sum			52,000	38,000	261,000		34,000	145,000
Pollutant weight in all flow			1,800,000	1,300,000	9,000,000		1,200,000	5,000,000

TABLE 7-8 COST-EFFECTIVENESS CALCULATION FOR LEACHATE TREATMENT SYSTEMS (Continued)

Pollutant weight (organic and inorganic	37,300,000	7,500,000	3,460,600,000		3,300,000	3,423,200,000
Incremental removal (PE) for 528 plants						37,400,000
Annualized costs for all plants						286,400,000
CE ($/PE)						7.66
@ each plant: investment ($)			806,000			
land costs (20% of abov (20% of above) ($)			161,200			
O&M cost ($/y)			286,000			
monitoring cost ($/y)			5,000			
annualized cost for each plant ($/y)			542,472			
CE ($/PE) without modified air stripping & aerated equalization						71.60

Data sources: raw waste conc.(Table 5-8 & 5-9), performance (Table 6-5 with Lucas' modification of air stripping & aerated equalization). na = not analysed

* Allow for 365 days per year of leachate collection.

TABLE 7-9 COST EFFECTIVENESS CALCULATION FOR AQUEOUS TREATMENT SYSTEMS

Number of plants (N)	602
Wastewater flow (gpd) @ each plant (q)	45,500
Number of days/year in operation (d)	260
Annual flow (mgy) for all plants = N x q x d	7,122

No.	Pollutant Name	Toxic weighting factor	Raw wastewater concentration (ppb)	Raw wastewater concentration wtd. (ppb)	aqueous treatment system Removal	aqueous treatment system effluent conc. (ppb)	aqueous treatment system effluent conc. wtd.
1	CH2CL2 (METH)	2.9470000	4966	14635	0.39	3029	8927
2	DCB, 1,2-	0.0170000	34	1	na	34	1
3	TCA, 1,1,1-	0.0003000	1139	0	0.41	672	0
4	TCE	0.2070000	333	69	0.26	246	51
5	Chloroform	2.9520000	125	369	0.16	105	310
6	Chlorobenz.	0.0115000	94	1	na	94	1
7	DCA, 1,2-	0.5960000	62	37	0.00	62	37
8	DCA, 1,1-	0.0005600	98	0	0.29	70	0
9	TetraCE	0.7070000	279	197	0.21	220	156
10	T,-1,2-DCE	0.0005000	29	0	0.03	28	0
11	CCL4	1.4000000	54	76	na	54	76
12	TCA, 1,1,2-	0.9340000	29	27	0.08	27	25
13	Chloronapthalene	0.3500000	3519	1232	0.46	1900	665
14	TetraCA, 1,1,2,2-	3.2940000	13635	44914	0.49	6954	22906
15	Toluene	0.0004000	6110	2	0.41	3605	1
16	Napthalene	0.0090300	75	1	0.22	59	1
17	Benzene	0.8480000	2241	1900	0.31	1546	1311
18	Isophorone	0.0000100	501	0	na	501	0
19	Di-n-butylphthalate	0.0001650	220	0	0.26	163	0
20	Bis(2-eh) phthalate	2.1866700	129	282	0.42	75	164
21	Phenol	0.0021900	2208	5	0.56	972	2
22	Butyl benzyl ph	0.0254500	165	4	0.44	92	2
23	HCB	777.8000000	11	8556	na	11	8556
24	HCE	0.3050000	41	13	na	41	13
25	HCButadiene	0.6130000	157	96	na	157	96
26	Fluorene	0.1120000	13	1	0.16	11	1
27	Bis(2-CE)ether	0.4120000	286	118	na	286	118
28	Nitrophenol,2-	0.0017000	66	0	0		
29	Diphenylhydrzn,1,2-	1.0000000	19	19	0		
30	Dinitrotoluene,2,4-	0.0615000	57	4	na		
	Sum (organic)		37,000	73,000		21,000	43,000
	Annual loading in all flow		2,198,000	4,336,000		1,247,000	2,554,000

TABLE 7-9 COST EFFECTIVENESS CALCULATION FOR AQUEOUS TREATMENT SYSTEMS (Continued)

31 Antimony	0.0036200	4868	18	0.82	876	3
32 Arsenic	32.0290000	248	7943	na	248	7943
33 Cadmium	5.0900000	29582	150572	0.88	3550	18069
34 Chromium	0.0267000	798252	21313	0.83	135703	3623
35 Copper	0.4670000	268609	125440	0.93	18803	8781
36 Lead	1.7500000	40665	71164	0.91	3660	6405
37 Nickel	0.1140000	1306957	148993	0.53	614270	70027
38 Zinc	0.1190000	589130	70106	0.93	41239	4907
39 Silver	46.6670000	177	8260	na	177	8260
40 Mercury	505.0260000	25	12626	0.85	4	1894
41 Selenium	0.1600000	685	110	na	685	110
Sum (inorganic)		3,039,000	617,000		819,000	130,000
Annual loading in all flow		180,500,000	36,646,000		48,644,000	7,721,000
Annual loading (organic and inorganic)		182,698,000	40,982,000		49,891,000	10,275,000
Incremental removal (PE) for 602 plants						30,707,000
Annualized costs for all plants						342,900,000
CE ($/PE)						11.17
@ each plant: investment ($)				767,002		
land costs (20% of above) ($)				153,400		
O&M cost ($/y)				325,310		
monitoring cost ($/y)				5,000		
annualized cost for each plant ($/y)				569,615		

Data sources: raw waste conc.(Tables 5-16 & 5-17), performance (Table 6-11). na = not analysed.

7.5 SUMMARY

- Treatment costs were developed based on treatment technologies that correspond to the common type of facilities operating in the HWT industry. Cost estimates developed for each subcategory were:

Subcategory	Investment, $	Operating Costs, $/yr	Annualized Cost, $/yr
Leachate Treatment	806,000	286,000	542,500
Scrubber Wastewater	1,501,000	381,000	854,300
Aqueous Treaters	767,000	325,000	569,600

- Leachate treatment could increase municipal landfill tipping fees.

- Implementation of the model wastewater treatment technologies would result in a net decrease in air emissions and increases in the amount of solid wastes generated and energy consumed. Air emissions potentially could be reduced by 39.6 million pounds of volatile pollutants per year. The amount of additional sludge generated could be as high as 380,000 metric tons per year. The amount of increased energy consumed as a result of possible regulations could total 91,000 barrels of No. 2 fuel per year. These conservative estimates assumed that no treatment is currently in place.

- The cost of implementing the model technologies is modest compared to average revenues for the HWT industry. The average incinerator would have to increase revenues by 4.7 percent to cover control costs. A municipal landfill and hazardous waste landfill would increase tipping fees by 35.5 and 3.8 percent, respectively. An aqueous treater would be required to increase revenues by 3.0 percent to cover control costs.

8.0 ENVIRONMENTAL ASSESSMENT

The purpose of this chapter is to evaluate the environmental impact of direct and indirect discharges of wastewater from the hazardous waste treatment industry at raw and treated effluent levels. Evaluations are on a subcategory basis for the three major subgroups comprising the HWT industry: landfill leachate treatment, scrubber wastewater, and aqueous waste.

The evaluations for subcategories are in two parts: direct discharge and indirect discharge assessments. The direct discharge analyses use average effluent concentrations and plant flow information to provide a criteria comparison with effluent levels, and an estimation of stream dilution required so as not to exceed these instream criteria. Total pollutant loadings are also calculated for comparison to other industries (primary and secondary [304(m)]). The second part of these evaluations examine the effects of HWT indirect discharges on publicly-owned treatment works (POTWs) and the environment. These assessments evaluate three potential impacts: (1) inhibition of POTW treatment processes; (2) contamination of sludge (thereby limiting its use); and (3) plant indirect discharge effects on surface waters. Additionally, total pollutant loadings to POTWs are estimated.

8.1 METHODOLOGY

The potential environmental impact associated with the direct and indirect discharge of wastewater from the hazardous waste treatment industry was evaluated on a subcategory-wide basis using raw and treated mean effluent concentrations, the number of plants, and average plant flows provided by the Industrial Technology Division (ITD). Both direct and indirect discharge analyses evaluated priority and nonconventional pollutants. The direct analyses employed a critical stream dilution/required stream flow model; the indirect analyses used a POTW model to predict effects due to discharge into POTWs and, ultimately, into receiving streams. These evaluations provide a general indication of the extent to which the receiving streams and POTWs could be affected by raw and treated wastewater discharges from this industry.

8.1.1 Direct Discharge Analysis

The direct discharge analyses by subcategory, at both raw and treated discharge levels, included: (1) a comparison of effluent concentrations to acute criteria/toxicity levels; (2) the calculation of ratios of detected effluent concentrations to chronic aquatic life, human health (water & organisms), and drinking water criteria/standards/toxicity levels; (3) the calculation of a required stream flow using the largest ratio of concentration/criteria (critical stream dilution factor) and average plant flow, indicating the stream flow required to dilute the effluent concentrations to a level equal to the lowest criteria/toxicity level (i.e., chronic, human health, drinking water); and (4) the calculation of total pollutant loadings to receiving waters for pollutants evaluated in the model (i.e., pollutants that had criteria for comparison).

8.1.2 Indirect Discharge Analysis

The indirect discharge analyses step of both raw and treated discharges, through the use of a POTW/water quality model, included: (1) the determination of potential inhibition of POTW treatment process (determined by comparing calculated influent pollutant levels with available inhibition levels); (2) an evaluation of potential contamination of POTW sludge and thereby limiting its use (determined through comparison of expected pollutant concentrations in POTW sludge with sludge contamination levels); (3) the determination of effects of the resultant POTW discharge on surface waters (determined through comparison of calculated POTW effluent concentrations with acute water quality criteria/toxicity levels for aquatic life, and calculated instream concentrations under low stream flow conditions with chronic aquatic life, human health, and drinking water criteria/standards/toxicity levels; and (4) the calculation of loadings of pollutants with criteria to POTWs.

Receiving stream characteristics and typical POTW flows used in the indirect analyses were obtained from EPA's IFD and GAGE files. These characteristics were based on the median POTW receiving industrial discharges (1 MGD) and its corresponding median low (7Q10) stream flow (12 MGD).

8.2 RESULTS OF ENVIRONMENTAL ASSESSMENT

8.2.1 Landfill Leachate Subcategory

Landfill leachate treatment facilities provide collection and treatment of aqueous discharge from on-site, commercial, municipal, private, hazardous, industrial, and/or Subtitle D landfills. These discharges can include leachate collected at the bottom of the landfill and any groundwater removed from the water table. Detailed results are compiled in Appendix E.

8.2.1.1 Direct Dischargers

Raw--The projected water quality impacts from untreated (raw) wastewater discharges from landfill leachate treaters is significant for all sizes of receiving streams. The most severe impact is from PCB-1242, which would require a stream flow of roughly 33,000,000 million gallons per day (over 100 times greater than the flow of the Mississippi River at New Orleans) to reduce the raw effluent concentration to a level less than EPA's human health criterion for carcinogenicity protection (risk level of 10^{-6}). Of the 149 pollutants with human health and/or aquatic life criteria/toxicity levels, 111 are discharged at levels greater than these levels:

- 70 pollutants (including 41 carcinogens) have projected human health impacts for streams with flows of 33,000,000 MGD and less.
- 39 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 43,000.
- 87 pollutants have projected long-term (chronic) aquatic life impacts for streams with flows of 186,000 MGD and less.
- 32 pollutants have projected drinking water impacts from streams with less than 59 MGD flow.

Treated--The current level of treatment for wastewaters from the landfill leachate subcategory reduces the total toxic pollutant loading from 109,000 to 70,700 lb/day (35 percent). Of the 149 pollutants with criteria, 107 exceed at least one of the four types of criteria/toxicity levels evaluated:

- 65 pollutants (including 41 carcinogens) have projected human health impacts for streams with flows of 28,700,000 MGD and less.
- 35 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 38,000.
- 76 pollutants have projected long-term (chronic) aquatic life impacts for streams with flows of 162,000 MGD and less.
- 31 pollutants have projected drinking water impacts from streams with less than 59 MGD flow.

Pollutant Loadings to Water (lbs/day)

Loading Category	Raw	Treated
Priority organics	16,168	7,886
Non-priority organics	54,470	47,162
Priority inorganics	2,979	2,316
Non-priority inorganics	35,080	13,310
Totals	108,697	70,674

The following is a narrative comparison of the direct landfill leachate subcategory priority pollutant loadings to other regulated industries:

Priority Organics--The raw loading of over 16,000 lbs/day is comparable to the raw loading of the petroleum refining industry (the fourth largest of the BAT industries). The loading under existing treatment (7,886 lbs/day) is greater than all of the primary industrial loadings combined at BAT.

Priority Inorganics--The raw loading of 2,979 lbs/day is comparable to the aluminum forming raw loading (ranked in the lower half of the BAT industries). The treated loading of 2,316 lbs/day is comparable to the iron and steel industrial loading at BAT (the fifth largest of the BAT industries).

8.2.1.2 Indirect Dischargers

Indirect dischargers were evaluated based on projected discharges to a model 1 MGD POTW and a 12 MGD receiving stream (representing median sizes for POTWs receiving indirect discharges from industrial sources).

Raw--The water quality impacts of untreated (raw) wastewater to POTWs from this subcategory are less significant than those projected for direct dischargers. Only 34 of the 149 pollutants with criteria/toxicity levels exceeded one or more of these levels:

- 24 pollutants (including 21 carcinogens) have projected human health impacts with exceedance factors of up to 2,700,000.
- 9 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 1,300.
- 14 pollutants have projected long-term (chronic) aquatic life impacts with exceedance factors of up to 15,000.
- 4 pollutants are projected to cause drinking water impacts.
- 4 inorganic pollutants are projected to cause potential inhibition of wastewater treatment process operations.
- 1 inorganic pollutant is projected to cause potential sludge contamination.

Treated--Current treatment of indirect discharges reduces toxic pollutant loadings by 35 percent (from 223,000 to 145,000 lb/day). Exceedances of water quality criteria and toxicity levels are also reduced; however, not significantly:

- 18 pollutants (including 17 carcinogens) have projected human health impacts with exceedance factors of up to 2,600,000.
- 7 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 1,130.
- 10 pollutants have projected long-term (chronic) aquatic life impacts with exceedance factors of up to 13,000.
- 2 pollutants are projected to cause drinking water impacts.
- 3 inorganic pollutants are projected to cause potential inhibition of wastewater treatment process operations.
- 1 inorganic pollutant is projected to cause potential sludge contamination.

An additional 84 pollutants were detected in discharges from this subcategory, but do not have any toxic levels or criteria for comparison.

Pollutant Loadings to Water (lbs/day)

Loading Category	Raw	Treated
Priority organics	33,179	16,181
Non-priority organics	111,773	96,779
Priority inorganics	6,133	4,753
Non-priority inorganics	71,984	27,311
Totals	223,069	145,024

A narrative comparison of the indirect landfill leachate priority pollutant loadings to regulated industries is presented below:

Priority Organics--A raw loading of 33,179 lbs/day is slightly less than that of the metal finishing (the third largest of the regulated industries indirect loadings). At treated levels, the loading of 16,181 lbs/day is comparable to the PSES loading of the pulp and paper industry (the largest indirect loading from regulated industrial categories).

Priority Inorganics--The raw loading of 6,133 lbs/day is about a third larger than that discharged by the aluminum forming industry (ranked in the lower half in terms of raw loadings). Under existing treatment, the loading of 4,753 lbs/day is greater than any of the primary industrial PSES loadings, with the exception of the metal finishing industry.

8.2.2 Scrubber Wastewater Subcategory

Incinerator scrubber wastewater treatment facilities are limited to those facilities treating only incinerator scrubber wastewater or on-site generators of incinerator scrubber wastewaters that are combined with other wastewater for treatment. Detailed results are presented in Appendix F.

8.2.2.1 Direct Dischargers

Raw--Projected water quality impacts from direct discharges of raw scrubber wastewater are significant from streams with flows less than 44,000 MGD. Of the 29 pollutants with criteria or toxicity levels, 27 of these exceed these levels (2 additional pollutants do not have criteria/toxicity levels):

- 13 pollutants (including 5 carcinogens) have projected human health impacts for streams with flows of 44,000 MGD and less.
- 9 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 1,325.
- 20 pollutants have projected long-term (chronic) aquatic life impacts for streams with flows of 616 MGD and less.
- 11 pollutants have projected drinking water impacts from streams with less than 51 MGD flow.

Treated--After treatment, loadings from direct discharges are reduced significantly from 45,700 to 1,040 lb/day (almost 98 percent). While the total number of pollutants that exceed at least one type of criterion/toxicity level is reduced only moderately (from 27 to 19), the magnitudes of these exceedances are reduced by several orders of magnitude:

- 12 pollutants (including 5 carcinogens) have projected human health impacts for streams with flows of 440 MGD and less.
- 5 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 2 to 16.
- 12 pollutants have projected long-term (chronic) aquatic life impacts for streams with flows of 16 MGD and less.
- 5 pollutants have projected drinking water impacts from streams with less than 1.1 MGD flow.

Pollutant Loadings to Water (lbs/day)

Loading Category	Raw	Treated
Priority organics	151	14
Non-priority organics	439	50
Priority inorganics	20,539	254
Non-priority inorganics	24,547	722
Totals	45,676	1,040

The following is a narrative comparison of the scrubber wastewater treatment priority pollutant loadings to other regulated industries.

Priority Organics--The raw loading of 151 lbs/day is comparable to the raw loading of the plastics molding and forming industry (ranked in the lower third of the primary industries). The loading under existing treatment (14 lbs/day) is comparable to the copper forming industrial loading at BAT (which is also ranked in the lower third).

Priority Inorganics--The raw loading of 20,539 lbs/day is comparable to the raw loading of the inorganic chemicals industry (ranked in the upper half of the primary industries), and the treated loading of 254 lbs/day is almost twice that of the electrical components industry at BAT (ranked in the middle of the primary industries).

8.2.2.2 Indirect Dischargers

Indirect dischargers were evaluated based on projected discharges to a model 1 MGD POTW and a 12 MGD receiving stream (representing median sizes for POTWs receiving indirect discharges from industrial sources).

Raw--The water quality impacts of untreated (raw) wastewater to POTWs from this subcategory are much less significant than those projected for direct dischargers. Only 11 of the 29 pollutants with criteria/toxicity levels exceeded one or more of these levels:

- 3 pollutants (including 2 carcinogens) have projected human health impacts with exceedance factors of up to 2,230.
- 6 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 27.
- 7 pollutants have projected long-term (chronic) aquatic life impacts with exceedance factors of up to 18.

- 1 pollutant is projected to cause drinking water impacts.
- 4 inorganic pollutants are projected to cause potential inhibition of wastewater treatment process operations.
- 6 inorganic pollutants are projected to cause potential sludge contamination.

Treated--Current treatment of indirect discharges reduces toxic pollutant loadings by almost 98 percent (from 9,000 to 205 lb/day). Exceedances of water quality criteria and toxicity levels are also significantly reduced:

- 2 pollutants (both carcinogens) have projected human health impacts with exceedance factors of 2 and 22.
- No pollutants are projected to cause short-term (acute) or long-term (chronic) aquatic life or drinking water impacts in receiving streams.
- 1 inorganic pollutant is projected to cause potential inhibition of wastewater treatment process operations.
- 1 inorganic pollutant is projected to cause potential sludge contamination.

Pollutant Loadings to Water (lbs/day)

Loading Category	Raw	Treated
Priority organics	30	3
Non-priority organics	87	10
Priority inorganics	4,048	50
Non-priority inorganics	4,837	142
Totals	9,002	205

A narrative comparison of the indirect priority pollutant loading of the scrubber wastewater treatment subcategory with other industries is presented below:

Priority Organics--A raw loading of 30 lbs/day is less than any of the primary raw organic industrial loadings with the exception of the aluminum forming industry (3 lbs/day) and industries discharging essentially no organics. The treated loading of 3 lbs/day is comparable to the copper forming industry at PSES (the lowest of the primary industries with non-zero levels).

Priority Inorganics--The raw loading of 4,048 lbs/day is slightly less than that discharged by the aluminum forming industry (ranked in the middle in terms of inorganic loadings). Under existing treatment, the loading of 50 lbs/day is comparable to the PSES loading of the foundries industry (also ranked in the middle for inorganic loads at PSES).

8.2.3 Aqueous Hazardous Waste Subcategory

Aqueous hazardous waste treatment facilities provide physical, chemical, and/or biological treatment of hazardous and nonhazardous wastewaters, including leachate from on-site and off-site landfills and process wastewaters from on-site and off-site manufacturing operations. Whereas leachate treatment facilities handle only wastewater generated on-site, commercial aqueous treaters handle a variety of wastewaters, including leachates. Detailed results are presented in Appendix F.

8.2.3.1 Direct Dischargers

Raw--Aqueous hazardous waste treatment facilities can adversely impact receiving streams with flows less than 5,130 MGD, based on the evaluation of untreated, or raw, discharges. Of the 77 pollutants with human health and/or aquatic life criteria/toxicity levels that have been detected in the wastewater from this subcategory, 55 are discharged at levels that cause exceedances (6 additional detected pollutants have no applicable criteria or toxicity levels):

- 31 pollutants (including 21 carcinogens) have projected human health impacts for streams with flows of 5,130 MGD and less.
- 17 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 15,000.
- 36 pollutants have projected long-term (chronic) aquatic life impacts for streams with flows of 1,224 MGD and less.
- 22 pollutants have projected drinking water impacts from streams with less than 726 MGD flow.

Treated--After treatment, loadings from direct discharges are reduced by almost 78 percent (from 198,000 to 44,400 lb/day). While the total number of pollutants that exceed at least one type of criteria/toxicity level is similar to untreated discharges (53 and 55, respectively), the magnitudes of these exceedances are reduced by more than 50 percent:

- 28 pollutants (including 21 carcinogens) have projected human health impacts for streams with flows of 2,090 MGD and less.

- 16 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 1,044.
- 33 pollutants have projected long-term (chronic) aquatic life impacts for streams with flows of 175 MGD and less.
- 21 pollutants have projected drinking water impacts from streams with less than 124 MGD flow.

Pollutant Loadings to Water (lbs/day)

Loading Category	Raw	Treated
Priority organics	1,283	737
Non-priority organics	9,635	2,951
Priority inorganics	99,880	26,994
Non-priority inorganics	87,181	13,716
Totals	197,979	44,398

The following is a narrative comparison of the aqueous waste treatment priority pollutant loadings to other regulated industries.

Priority Organics--The raw loading of 1,283 lbs/day is 1.5 times the loading of the copper forming industry and 60 percent of the foundries loading under raw discharge conditions (ranked eighth and seventh, respectively). The treated loading of 737 lbs/day is comparable to the BAT loading of the textiles industry (ranked third).

Priority Inorganics--The raw loading of 99,880 lbs/day is approaching the raw industrial loading of the organics/P&SF industry (ranked fifth at 125,000 lbs/day). The treated loading of 26,994 lbs/day is greater than any reported primary BAT industrial loading, and slightly greater than the total inorganic loading of POTWs discharging to surface waters nationwide.

8.2.3.2 Indirect Dischargers

Indirect dischargers were evaluated based on projected discharges to a model 1 MGD POTW and a 12 MGD receiving streams (representing median sizes for POTWs receiving indirect discharges from industrial sources).

Raw--The water quality impacts of untreated (raw) wastewater to POTWs from this subcategory are less significant than those projected for direct dischargers. Only 22 of the 77 pollutants with criteria/toxicity levels exceeded one or more of these levels:

- 12 pollutants (including 10 carcinogens) have projected human health impacts with exceedance factors of up to 260.
- 7 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 134.
- 10 pollutants have projected long-term (chronic) aquatic life impacts with exceedance factors of up to 39.
- 4 pollutants are projected to cause drinking water impacts.
- 6 inorganic pollutants are projected to cause potential inhibition of wastewater treatment process operations.
- 6 inorganic pollutants are projected to cause potential sludge contamination.

Treated--Current treatment of indirect discharges reduces toxic pollutant loadings by almost 78 percent (from 1,172,000 to 263,000 lb/day). Exceedances of water quality criteria and toxicity levels are also reduced; however, not as significantly:

- 11 pollutants (including 10 carcinogens) have projected human health impacts with exceedance factors of up to 116.
- 5 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 16.
- 5 pollutants have projected long-term (chronic) aquatic life impacts with exceedance factors of up to 9.
- 2 pollutants are projected to cause drinking water impacts.
- 5 inorganic pollutants are projected to cause potential inhibition of wastewater treatment process operations.
- 5 inorganic pollutants are projected to cause potential sludge contamination.

Pollutant Loadings to Water (lbs/day)

Loading Category	Raw	Treated
Priority organics	7,593	4,361
Non-priority organics	57,035	17,469
Priority inorganics	591,246	159,791
Non-priority inorganics	516,073	81,193
Totals	1,171,947	262,814

A narrative comparison of indirect priority pollutant loadings from the aqueous waste treatment subcategory to primary industries is presented below.

Priority Organics--A raw loading of 7,593 lbs/day is about 1.5 times that of the textiles industry at raw, and about 45 percent of the raw pulp and paper industrial loading (ranked fifth and fourth, respectively). The treated loading of 4,361 lbs/day is greater than any reported raw primary industrial PSES loadings with the exception of the pulp and paper industry.

Priority Inorganics--The raw loading of 591,246 lbs/day is comparable to the raw loading of the metal finishing industry (ranked second). The treated loading of 159,791 lbs/day is greater than all primary PSES loadings combined.

8.3 NONWATER QUALITY ENVIRONMENTAL ASPECTS

The elimination or reduction of one form of pollution may create or aggravate other environmental problems. Therefore, Sections 304(b) and 306 of the Clean Water Act (CWA) require the U.S. Environmental Protection Agency (EPA) to consider nonwater quality environmental aspects of certain regulations. In compliance with these provisions, EPA has considered the effect of possible regulations on air pollution, solid waste generation, and energy consumption. The nonwater quality environmental aspects associated with possible regulation are described below.

8.3.1 Air Pollution

Implementation of the model wastewater treatment technologies would result in an overall reduction in air emissions. This is largely due to the incorporation of effective air pollution controls for the model leachate treatment technologies. For example, existing leachate treaters are known to operate wastewater treatment units, such as aerated equalization basins and aerated lagoons, that are open to the atmosphere. The model technology requires air stripping in a covered unit with venting to existing air pollution control devices. Since the air stripper is located at the head of the treatment train, the possibility of significant air emissions from downstream units is minimized. The net effect would be a reduction from current air emissions of 39.6 million pounds to 1.2 million pounds per year if the assumption is made that no treatment is in-place prior to implementation of a possible regulation.

The technologies recommended for the aqueous and scrubber subcategories are similar to those technologies currently used by the hazardous waste treatment (HWT) industry. The Development Document for Effluent Limitations and Standards for the Metal Finishing Point Source Category associated no significant air emissions with the unit operations recommended here as model HWT technologies. However, the EPA Office of Air Quality Planning and Standards (OAQPS) is developing regulations to require the enclosing of hazardous waste storage and treatment units. Preliminary information developed by OAQPS suggests that no significant changes in air emissions would result from operation of aqueous and scrubber subcategory technologies.

8.3.2 Solid Waste

EPA considered the effect possible regulations would have on the production of solid waste, including hazardous waste defined under Section 3001 of the Resource Conservation and Recovery Act (RCRA). EPA estimates that the total solid waste, including hazardous waste, resulting from a possible regulation would be significant for facilities that do not have treatment in-place. For example, an aqueous hazardous waste treater would generate 420 metric tons of sludge (total sludge generated, dewatered to 20 percent solids) annually as a result of implementing the model technology. Similarly, a facility in the leachate subcategory would generate 240 metric tons (includes both primary and biological treatment sludges, dewatered to 20 percent solids) annually. The model technologies recommended for the scrubber subcategory would result in no sludge generation. An inventory of treatment systems currently in use by the HWT industry is not available. However, if the assumption is made that no treatment is in-place, then a possible regulation would result in 380,000 metric tons of sludge generated annually.

8.3.3 Energy Requirements

Implementation of the model wastewater treatment technologies would increase energy consumption over present industry use. For example, a typical aqueous treater would consume 37 barrels of No. 2 fuel oil per year over current levels if no treatment were in-place. Similarly, facilities in the leachate and scrubber subcategories would consume 127 and 12 barrels of No. 2 fuel oil per year, respectively. An inventory of treatment systems currently in use by the HWT industry is not available. However, if the assumption is made that no treatment is in-place, then a possible regulation would result in an increased consumption of 91,000 barrels of No. 2 fuel per year.

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